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FLEET RELIABILITY ASSESSMENT PROGRAM. VOLUME 5. AN/URC-62 VLF F--ETC(U)

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VOLUME 5

FINAL REPORT

A068858

FLEET RELIABILITY ASSESSMENT PROGRAM

AN/URC-62
VLF FLEET BROADCAST SYSTEM

NAVAL WEAPONS SUPPORT CENTER
CRANE, INDIANA

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Published by direction of Commander, Naval Electronics Systems Command.

VOLUME 5

(9) # FINAL REPORT.

(6) # FLEET RELIABILITY ASSESSMENT PROGRAM.

Volume 5.

AN/URC-62 VLF FLEET BROADCAST SYSTEM. Volume 5.

NAVAL WEAPONS SUPPORT CENTER
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(12) 118 p.

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FLEET RELIABILITY ASSESSMENT PROGRAM

DEPARTMENT OF THE NAVY

NAVAL ELECTRONIC SYSTEMS COMMAND

PREPARED UNDER THE DIRECTION OF

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RECORD OF CHANGES

CHANGE NO.	DATE	TITLE OR BRIEF DESCRIPTION	ENTERED BY

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1-1 CLARINET VERDIN, AN/URC-62.

1-1.1 Verdin is a Very Low Frequency (VLF) Fleet broadcast system intended primarily for transmission to submerged submarines. Four separate equipments make up the Verdin System. Of these, only two were operationally deployed during the FRAP study, the AN/ART-50 airborne transmitter and the AN/WRR-7 shipboard receiver.

SECTION II - RESULTS.

2-1 AIRBORNE AN/ART-50 VLF TRANSMITTER.

2-1.1 FRAP SAMPLE RESULTS. The estimated mean time between operational failures is 150 hours. The estimated mean time between equipment failures is 169 hours. The AN/ART-50 is considered to be meeting the piece-parts predicted (MIL-HDB-217) MTBF of 169 hours but not the specified MTBF of 750 hours. Seventy per cent (70%) of the observed failures were in the Frequency Time Standard. Although the ART-50 has an estimated mean time between repair of 4 hours and does not meet the specified MTTR of .36 hours, this is not considered serious as this includes other times besides actual repair time with most of it being on the ground.

2-1.2 REPAIR DEPOT DATA. Fifty-seven percent (57%) of the significant problem areas at the repair depot were done to FTS modules.

2-1.3 CORRECTIVE ACTION. The most cost-effective corrective action to improve the ART-50 performance is to provide a hot spare (discussed in paragraph 6-1.1 below).

2-2 SHIPBOARD AN/WRR-7 VLF RECEIVER.

2-2.1 FRAP SAMPLE RESULTS. The estimated mean time between operational failures is 2432 hours and is improving as the WRR-7 failure times follow Weibull distribution with $B = .416$. The estimated mean time between equipment failures is 2350 hours assuming an exponential distribution. The WRR-7 is considered to be meeting its specified MTBF of 1000 hours. The estimated mean time to repair and mean down time are 2.3 and 336 hours, respectively. Although the estimate MTTR does not meet the specified .62 hours, the MDT of 336 hours has a much greater effect on operational availability.

2-2.2 REPAIR DEPOT DATA. The R-1738/WR radio set is the largest current problem area.

2-2.3 CORRECTIVE ACTION. The most cost-effective action to improve the operational availability of the WRR-7 is to increase sparing levels to reduce the down-time since only modest gains in Ao can be achieved through the MTBF inprovements that are likely (See Figure 5-7.1 and Table 5-10.2). However, effective fixes for the receiver power supply P/N 616-1789 and the SMO P/N 792-6701 would significantly reduce the WRR-7 cost-to-repair.

SECTION III - SYSTEM DESCRIPTION

3-1 AN/URC-62, CLARINET VERDIN SYSTEM

3-1.1 FUNCTIONAL DESCRIPTION. Clarinet Verdin, AN/URC-62, is a Fleet broadcast system operating in the VLF range (3KHz - 30KHz). The VLF range is noted for long distance groundwave propagation, relative immunity from ionospheric disturbances and sunspots, and significant wave penetration into salt water. The later effect allows submarines to receive VLF signals without surfacing. The VLF range has severe natural interference from thunderstorms and narrow bandwidths, an effect which arises from the basic nature of tuned resonant circuits and the reactive nature of VLF antennas Verdin provides multiple channel capability, noise tolerant encoding/decoding techniques, and encryption capability through the use of computerized message processing and phase-shift keying using a concept called "minimum shift keying". The AN/URC-62 system is broken into transmit only and receive only sections, each with its own nomenclature. Previous to Verdin, VLF systems were low speed, single channel systems.

3-1.2 EQUIPMENT DESCRIPTION. The AN/URC-62 addresses the problems of the VLF band with a family of sophisticated transmitters and receivers. All members of the Verdin family contain an electronic digital computer, called a "processor", and ultra-stable Frequency Time Standard (FTS) units. A large number of modules are common throughout the family and a single depot level repair facility serves them all. Each family member has its own nomenclature. The two Verdin family equipments studied by FRAP are the AN/ART-50 transmitter and the AN/WRR-7 receiver.

3-2 AN/ART-50 VLF TRANSMITTER

3-2.1 DESCRIPTION. The AN/ART-50 is the flying transmitter for the verdin system. It consists of five major sections (WRA's) mounted in an equipment rack. (See Figure 5-3.1) A typical installation is in the cargo hold of a converted turboprop cargo aircraft. Rather than function as a stand-alone transmitter, current installations use the AN/ART-50 as an exciter for a power amplifier which drives an extendable antenna. The antenna, when deployed, trails out behind the aircraft for a distance of up to five miles. A second antenna is played out above the main antenna to serve as a tuning stub. This smaller antenna may be up to one mile in length. These large physical dimensions are necessitated by the low frequencies used. While the techniques used in the power amplifier and antenna systems are revivals of those used in the earliest days of radio, the AN/ART-50 is the embodiment of the latest developments in computerized signal processing, information theory, and encoding algorithms. The transmitter is in an area pressurized and air conditioned for the benefit of the operating crew. In-flight repair is possible by module level replacement from a stock of ready spares. The system is fully powered throughout the flight and is thoroughly tested during a two-hour preflight shakedown. The majority of the O-level maintenance performed on the system is accomplished by the ground crew.

3-2.2 FRAP SAMPLE. Data was taken from nine aircrafts of VQ-4 TACAMO Squadron based at the Naval Air Training Center, Patuxent River, Maryland.

3-3 AN/WRR-7 VLF RECEIVER

3-3.1 DESCRIPTION. The AN/WRR-7 (See Figure 5-3.2) is the shipboard receiver for the AN/ART-50. It consists of five major assemblies (WRA's). Only the FTS is directly

interchangeable with that used in the transmitter, but card and module level interchangeability with other AN/URC-62 equipment has been carried as far as practical. The AN/WRR-7 can receive standard digital modulations such as Frequency Shift Keying (FSK), but is intended primarily as an Minimum Shift Keying (MSK) receiver. When working with MSK, coherent detection, a technique using the FTS's super stable time signals, gives the system enough noise tolerance to allow reception of encrypted (COMSEC) traffic. The system is intended primarily for installation aboard submarines using external loop or floating wire antennas. The receiver is typically mounted in an equipment rack in the radio room of a submarine. Personnel work in this area, but radio rooms are typically crowded with equipment and ventilation is at a premium. Repair is by module replacement from a stock of ready spares. Radio room personnel normally perform all O-level maintenance on the system. A typical mission may be 60 days in duration. FRAP shows a duty cycle of 0.443.

3-3.2 FRAP SAMPLE. A total of 14 sample WRR-7's were monitored on a 8 sample platforms, Eleven sample equipments were in the Atlantic Fleet aboard 4 submarines and 2 tenders and 3 sample equipments were in the Pacific Fleet aboard 2 submarines.

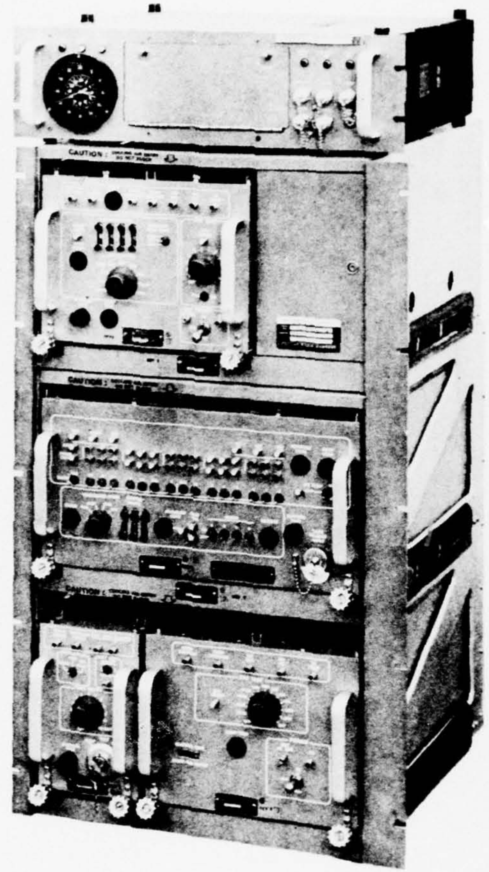


Figure 5-3.1

DIGITAL DATA TRANSMITTING SET AN/ART-50

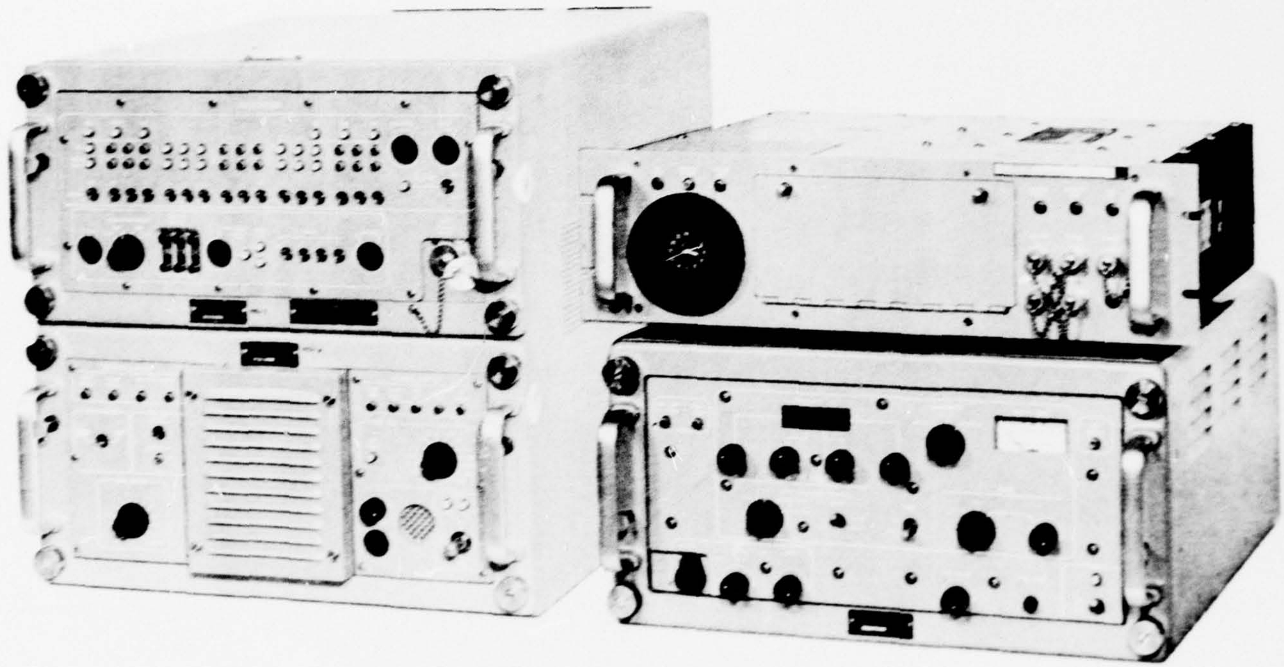


Figure 5-3.2

DIGITAL DATA RECEIVING SET AN/WRR-7

SECTION IV - RELIABILITY MODELS

4-1 AN/ART-50, VLF TRANSMITTER

4-1.1 MISSION DESCRIPTION. As currently used, the AN/ART-50 is powered up approximately two hours before take-off during preflight testing of on-board equipment. It remains fully powered during the mission, typically ten hours in duration, and is not powered down until post flight equipment shutdown. Although emergency bypass and patch-through operating modes are technically possible, flight crews advise that such operation is rare. In-flight repair is accomplished by substitution of modules and circuit boards from a stock of ready spares. Although box level (WRA level) substitutions in flight are possible, box level spares are not carried on board except for the Frequency/Time Standard (FTS), which has proved to be troublesome. Even in this case, box level substitution is considered to be a last resort.

4-1.2 RELIABILITY BLOCK DIAGRAM (WRA LEVEL). Figure 5-4.1 shows the five WRA sections of the AN/ART-50 in a series arrangement to indicate that all five sections must fully function for a successful mission. The AN/ART-50 modulator section, which performs the same function as a radio transmitter, resembles an audio system. Because of the low frequencies used by Verdin and the relatively low output power of the AN/ART-50, the large stress level shifts that usually are observed during transmitter ON-OFF cycling do not occur.

4-1.3 RELIABILITY BLOCK DIAGRAM (O-LEVEL). Instead of presenting a diagram down to the O-Level unit, the O-Level units within each WRA are listed in Figure 5-4.2 along with a reliability key (block) number, their failure rate, the number used, and O-Level nomenclature. All of the O-Level units within the Power Supply, the Control Unit, and the Modulator (WRA 2, 3, and 5, respectively) are serially connected as a failure of one O-Level unit would result in a system failure. However, the processor (WRA 4) a special purpose computer, is a large and multi-mode assembly. Normally, each operating mode of this WRA would be represented by a diagram for that mode only. However, as several of the modes were classified, all O-Level units of the processor are considered to be in series in order to eliminate possible classification problems. Thus, the entire AN/ART-50 reliability block diagram would be a series connection of the O-Level units given in Figure 5-4.2.

4-1.4 MATHEMATICAL MODEL. The relaibility of each O-Level unit (reliability key number in Figure 5-4.2) is expressed as

$$R_i = R_i^{n_i} \qquad (1)$$

where i is the ith O-Level and n_i the number of ith units used. Thus, the reliability of a WRA is the product of the reliabilities of the O-Level units within the WRA. For example, the reliability of WRA 1 is

$$R_{WRA\,1} = \prod_{i=28}^{45} R_i^{n_i} \qquad (2)$$

The reliability of the overall system may be expressed as a product of WRA reliability or as a product of O-Level unit reliabilities, i.e.

$$R_{SYS} = \prod_{i=1}^{5} R_{WRA_i} = \prod_{i=1}^{105} R_i^{n_i} \qquad (3)$$

If the exponential distribution of failure rates is assumed (constant failure rate), then

$$R_i = EXP(-\lambda_i t) \qquad (4)$$

where λ_i is failure rate of the ith 0-Level unit and t is the mission time. Of course, as R, the reliability, is probability of no failures at or prior to time t, 1-R is the probability of one or more failures at or prior to time t.

4-1.5 COMPUTER PROGRAM. A program to determine the reliability of the AN/ART-50 using equations (3) and (4) is listed in Figure 5-A.1 in Appendix 5A. The program is written in BASIC computer language and can be used on any system accepting this language. Figure shows the results of running this program with the information given in Figure 5-4.3. The failure rates are MIL-HDB-127 predictions obtained from Reliability analysis and MTBF prediction for Verdin Digital Data Communications System, AN/URC-62 - Volume I, dated 9 July 1976.

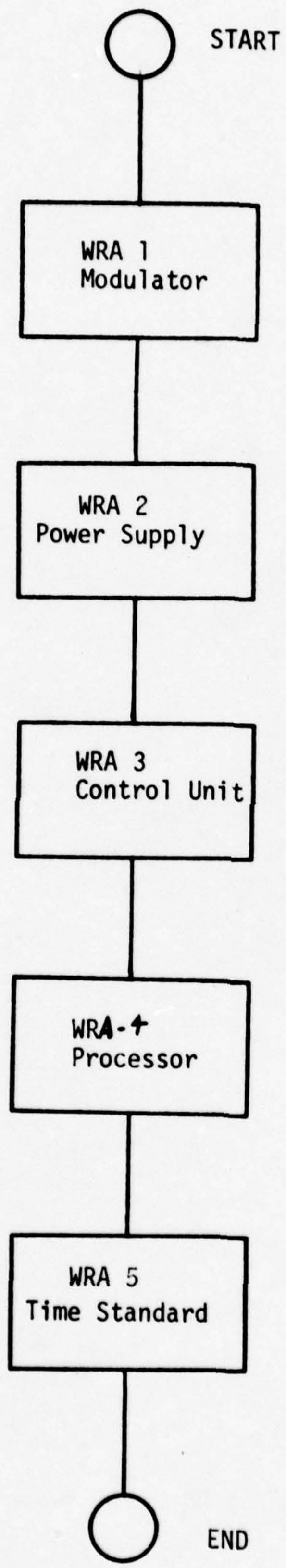
4-2 AN/WRR-7, VLF RECEIVER

4-2.1 MISSION DESCRIPTION. The AN/WRR-7 is designed to be fully powered throughout the entire mission of a patrol submarine (typically up to 90 days). In actual practice, only the FTS requires continuous power. The remainder of the receiver can be powered down when not in use. Patrol submarines usually carry dual AN/WRR-7 installations and probably do power down the standby system to reduce heat and noise in the radio room. FRAP data shows a duty cycle of .443. Repair is by card level substitution from a stock of ready spares carried on board. No box level (WRA) spares are carried.

4-2.2 RELIABILITY BLOCK DIAGRAM (WRA LEVEL). Figure 5-4.4 shows the WRA level reliability diagram for the AN/WRR-7. Each block is a box level replaceable unit. The serial chain arrangement indicates that all five boxes must function for a successful mission. Since operating personnel do not normally substitute at the WRA level, each box must be represented by a submodel which represents the performance of the WRA's component modules from a reliability view point.

4-2.3 RELIABILITY BLOCK DIAGRAM (0-LEVEL). As with the AN/ART-50, the Power Supply and FTS reliability diagrams serial chains of replaceable modules or cards. The Demodulator, likewise, must fully function for a mission success; it also is represented by a serial chain diagram. For reasons explained in Section 4-1.3, the processor model is assumed to be a serial chain. The receiver (WRA#1) model is clearly a serial chain except for the BFO/audio card, which is strictly a manual tuning aid. However, this card is tested during automated diagnostics and, if found defective, a shutdown for replacement would probably follow. For this reason, the BFO/audio card is included in the serial chain. Thus, all WRA's have serial chain reliability diagrams and are themselves connected in a serial chain. Therefore, the entire AN/WRR-7 reliability block diagram would be a series connection after 0-level units given in Figure 5-4.5.

4-2.5 COMPUTER PROGRAM. A program, written in BASIC language, to determine the reliability of the AN/WRR-7 is listed in Figure 5-A.2 in Appendix 5A. Figure 5-4.5 shows the results of running this program with the information given in Figure 5-4.5 with a full duty cycle. The failure rates and MIL-HDB-217 predictions obtained in paragraph 4-1.5 as described.



AN/ART-50
WRA Model
Figure 5-4.1

MODEL KEY NUMBER	O-LEVEL FAILURE RATE	NUMBER USED	WRA #	DESIG.	PART NAME	PART #
1	2.642	1	2	RA5	POWER SUPPLY -25V	784-3655
2	2.208	3	2	RA7	POWER SUPPLY +15V	784-3656
3	2.052	2	2	RA8	15 VOLTS FILTERS	784-3657
4	4.491	3	2	RA9	LAMP DRIVERS	784-3658
5	5.611	1	2	RB2	POWER SUPPLY -5.2V	784-3659
6	2.411	1	2	RB4	POWER SUPPLY +25V	784-3661
7	2.060	1	2	PV2	POWER SUPPLY MONITOR	784-4166
8	11.787	1	2		CHASSIS	784-5800
9	3.471	1	2	RB3	BATTERY CONVERTER	619-0996
10	6.486	1	2	RC3	BATTERY MODULE	609-4511
11	3.095	1	3	PF5	PROCESSOR INPUT	784-4004
12	4.053	1	3	PF8	PROCESSOR OUTPUT	784-4008
13	4.490	1	3	PF9	TIME BASE I	784-4010
14	3.394	1	3	PG2	TIME BASE II	784-4012
15	3.390	1	3	PG3	TIME BASE III	784-4014
16	5.533	2	3	PG4	CONTROL COUNTER	784-4016
17	6.463	1	3	PG5	PHASE 2 INTERFACE	784-4018
18	7.146	1	3	PG7	DEMULTIPLEXER	784-4020
19	2.889	1	3	PG8	FILTER	784-4022
20	3.799	1	3	PG9	ALARM	784-4024
21	7.261	1	3		CHASSIS	784-5750
22	3.428	1	3	TTY	TELETYPE INTERFACE	784-5336
23	3.498	1	3			784-5244
24	5.284	1	3	KG	KEY GENERATOR INTERFACE	784-5340
25	5.574	1	3	BDTL	BLACK DIGITAL	784-6444
26	6.382	1	3		WIRED BACKCAP	784-7611
27	17.202	1	3		WIRED PANEL	784-7745
28	3.735	1	1	PD9		784-3982
29	4.259	1	1	PE4	I/O FAULT	784-3988
30	3.853	1	1	PE5	SELF TEST	784-3990
31	3.788	1	1	PE9	MULTIPLEXER	784-3996
32	4.153	1	1	PF2	TIME BASE III	784-3998
33	4.318	1	1	PF3	TIME BASE I	784-4000
34	1.756	1	1	PF4	WAVEFORM GENERATOR	784-4002
35	1.838	1	1	PH2	MODULATOR V/Z	784-4026
36	2.881	1	1	PH3	MODULATOR CONTROL	784-4028
37	25.498	1	1	SMO	STABILIZED MASTER OSC.	792-6701
38	11.786	1	1		CHASSIS	784-7700
39	2.552	1	1		SHELF/BACKCAP	792-6366
40	3.297	1	1	PE3	HET 2	620-7111
41	2.834	1	1	HET1	POWER AMPLIFIER	620-7115
42	2.411	1	1	RB	POWER SUPPLY +25V	784-3661
43	2.052	1	1	RA8	POWER SUPPLY 15V	784-3657
44	3.471	1	1	RB3	BATTERY MODULE	619-0996

Figure 5-4.2 AN/ART-50 O-Levels

MODEL	KEY	NUMBER	O-LEVEL FAILURE RATE	NUMBER USED	WRA #	DESIG.	PART NAME	PART #
		45	6.518	1	1	RC3	BATTERY CONVERTER	609-4511
		46	4.491	4	1	RA9	POWER SUPPLY 5.2V	784-3658
		57	2.298	4	4	PJ7	READ/WRITE SWITCH	784-4048
		58	5.657	4	4	PE7	READ/WRITE DRIVER	784-3992
		59	2.468	8	4	PJ8	INHIBIT DRIVER	784-4050
		60	3.154	1	4	PN7	WRITE DRIVER	784-4104
		61	3.159	1	4	PD8	READ DRIVER	784-3980
		62	1.008	1	4	PD7	STROBE	784-3978
		63	1.515	1	4	PF7	MEMORY TIMING	784-4006
		64	2.657	3	4	PE8	DIODE BOARD	784-3994
		65	2.000	1	4	CORE	ARRAY, MAGNETIC	784-5626
		66	1.886	2	4	PD5	SENSE AMPLIFIER	784-3976
		67	3.509	1	4	PX2	CYCLE CONTROL I	784-4194
		68	3.099	1	4	PX5	CYCLE CONTROL II	784-4200
		69	3.758	1	4	PX4	R/S CYCLE CONTROL	784-4198
		70	2.887	1	4	PW7	I/O CONTROL	784-4188
		71	1.711	1	4	PW9	I/O SELECTOR	784-4192
		72	3.656	1	4	PV7	PT ADAPTER I	784-4174
		73	3.789	1	4	PV5	PT ADAPTER II	784-4172
		74	1.985	1	4	MTU	MAGNETIC TAPE UNIT	771-4616
		76	3.828	16	4	PY5	BIT MEMORY	784-4214
		78	3.190	1	4	PW8	I/O FAN-IN	784-4190
		79	3.735	1	4	PY3	PANEL INTERFACE	784-4210
		80	2.435	1	4	PY2	INSTRUCTION DECODER	784-4208
		81	3.806	1	4	PX9	TRANSFER CONTROL A	784-4206
		82	3.799	1	4	PX8	TRANSFER CONTROL Z	784-4204
		83	3.586	1	4	PX7	TRANSFER CONTROL B	784-4202
		84	3.616	1	4	PX3	C. TEST	784-4196
		85	3.968	2	4	PY4	COMPARATOR ACCUMULATOR	784-4212
		86	2.592	1	4	PV9	MTA SHIFT	784-4178
		87	1.887	1	4	PV8	MTA REGISTER	784-4176
		88	3.990	1	4	PW2	MTA TIMING	784-4180
		89	4.900	1	4	PW4		784-4184
		90	4.993	1	4	PW5		784-4186
		91	3.219	1	4	PV4	MODE INDICATOR	784-4170
		92	5.033	1	4	LDR	LAMP DRIVERS	784-4222
		93	26.645	1	4		CHASSIS	
		94	8.000	1	5	RVFR	RB VAPOR FREQ. REF.	617-6876
		95	7.484	1	5	VR	VOLTAGE REGULATOR	797-3632
		96	7.235	1	5		SERVO AMPLIFIER	797-3627
		97	1.182	1	5		SYNTHESIZER	606-9515
		98	6.395	1	5		R.F. AMPLIFIER	797-3628
		99	1.136	1	5		R.F. GENERATOR	606-9520
		100	6.675	1	5		THERMO CONTROL	606-9527

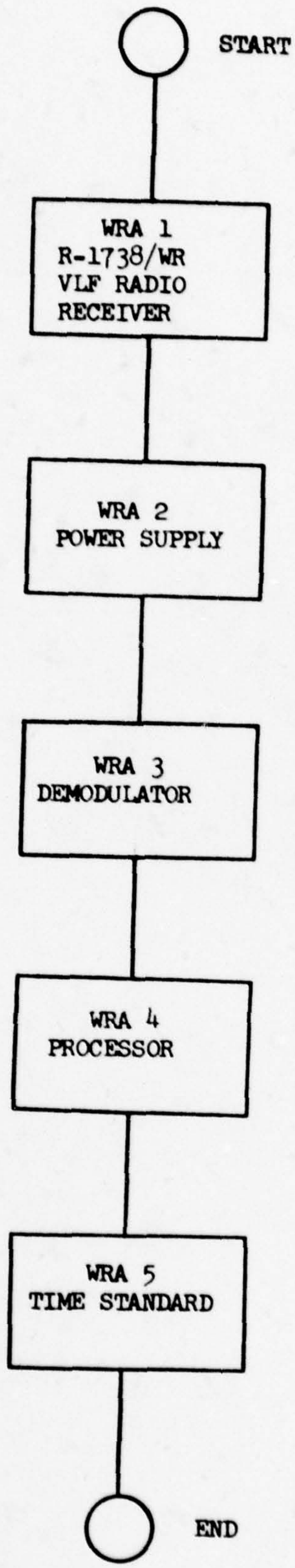
Figure 5-4.2 AN/ART-50 O-Level (Continued)

MODEL KEY NUMBER	O-LEVEL FAILURE RATE	NUMBER USED	WRA #.	DESIG.	PART NAME	PART #
101	3.926	1	5		AUXILIARY R.F. AMPLIFIER	609-1376
102	8.106	1	5		CLOCK DIVIDER	606-9521
103	.400	1	5		BATTERY MODULE	606-9524
104	4.238	1	5		BATTERY CHARGER	606-9523
105	11.197	1	5		POWER SUPPLY MODULE	606-9525
106	3.311	1	5		CLOCK	617-6154
107	3.981	1	5		THERMO-ELEC. COOLER	606-9526
108	7.383	1	5		CHASSIS	606-9513

Figure 5-4.2 AN/ART-50 O-Level (Continued)

```
RUN

 77/03/08. 16.18.44.
PROGRAM   ART50

INPUT MISSION LENGTH (IN HOURS) = ? 12

MEAN TIME BETWEEN FAILURES BY WRA (IN HOURS)
MODULATOR        POWER SUPPLY   CONTROL BOX    PROCESSOR       TIME STD.
939              1637           1016           407             1239

OVERALL SYSTEM MTBF =  169

OVERALL SYSTEM RELIABILITY FOR  12  HOUR MISSION =  .931


SBU       0.628 UNTS.

RUN COMPLETE.
```

Figure 5-4.3



AN/WRR-7
WRA Model
Figure 5-4.4

MODEL KEY NUMBER	O-LEVEL FAILURE RATE	NUMBER USED	WRA #	DESIG.	PART NAME	PART #
1	5.571	1	1	A2	R.F. AMPLIFIER	616-1629
2	1.180	1	1	A3	FIRST MIXER	616-1669
3	.990	1	1	A4	FIRST I.F. AMPLIFIER	616-1689
4	.724	1	1	A11	SECOND MIXER	616-1710
5	1.323	1	1	A9	FSK DETECTOR	616-1730
6	.405	1	1	A19	7.5 KHZ AMPLIFIER	616-1740
7	.376	1	1	A7	5 MHZ SWITCH/AMPLIFIER	616-1749
8	.101	1	1	A12	BFO/AUDIO	616-1760
9	.718	1	1	A10	AGC DETECTOR/AMPLIFIER	616-1770
10	3.706	1	1	A8	RECEIVER POWER SUPPLY	616-1789
11	1.618	1	1	A1	FRONT PANEL	616-1651
12	3.345	1	1		CHASSIS COMPONENTS	792-6377
13	.593	1	1	A13	SELF CHECK MULTIPLEXER	616-1810
14	.937	1	1	A14	SELF CHECK	616-1820
15	1.813	1	1	A5	SECOND I.F. AMPLIFIER	616-1829
16	1.520	1	1		BCD FREQUENCY CONTROL	616-1780
17	.490	1	1		RFI ASSEMBLY	616-1624
18	8.625	1	1	A6	STABILIZED MASTER OSC.	792-6701
19	1.573	1	3	TTY	TELETYPE INTERFACE	784-5336
20	1.682	1	3	BANL	BLACK ANALOG INTERFACE	784-5338
21	2.532	1	3	KGEN	KEY GENERATOR INTERFAC	784-5340
22	2.075	1	3	BDIG	BLACK DIGITAL INTERFAC	784-6444
23	1.291	1	3		WIRED BACKCAP ASSEMBLY	784-7611
24	.331	1	3		BACKPLANE	784-5244
25	2.209	2	3	PD9	WEIGHTING FUNCTION GEN	784-3982
26	1.686	1	3	PF9	TIME BASE I	784-4010
27	1.763	1	3	PG2	TIME BASE II	784-4012
28	1.698	1	3	PG3	TIME BASE III	784-4014
29	1.592	1	3	PJ9	ADC CONTROL	784-4052
30	1.665	1	3	PK2	ADC DETECTOR	784-4054
31	2.127	1	3	PK3	ADC MULTIPLEXER	784-4056
32	1.120	1	3	PK4	DIGITAL-ANALOG CONVERT	784-4058
33	2.743	1	3	PK5	BINARY AND TIMING	784-4060
34	1.969	2	3	PK7	DETECTOR B	784-4062
35	1.314	1	3	PK8	SYNCHRONIZING	784-4064
36	.940	1	3	PK9	AMPLITUDE MULTIPLIER	784-4066
37	1.969	1	3	PL2	DETECTOR A	784-4068
38	2.209	2	3	PL3	RESOLVER	784-4070
40	2.112	1	3	PL7	REGISTER TWO	784-4076
41	2.030	1	3	PL8	REGISTER THREE	784-4078
42	1.909	1	3	PL9	REGISTER FOUR	784-4080
43	1.904	1	3	PM2	REGISTER FIVE	784-4082
44	2.043	1	3	PM3	REGISTER SIX	784-4084
45	2.772	1	3	PM4	REGISTER SEVEN	784-4086

AN/WRR-7
O-Levels
Figure 5-4.5

MODEL KEY NUMBER	D-LEVEL FAILURE RATE	NUMBER USED	WRA #	DESIG.	PART NAME	PART #
46	2.267	1	3	PM5	ALARM PHASE TWO	784-4088
47	1.833	1	3	RB7	CONTROL PHASE TWO	784-5334
48	2.234	1	2	RA5	POWER SUPPLY, -25V	784-3655
49	1.593	3	2	RA7	POWER SUPPLY, +15V	784-3656
50	1.751	2	2	RA8	15 V FILTER	784-3657
51	3.141	4	2	RA9	LAMP DRIVER	784-3658
52	3.454	1	2	RB2	POWER SUPPLY, -5.2V	784-3659
53	1.947	1	2	RB4	POWER SUPPLY, +25V	784-3661
54	1.255	1	2	PV2	POWER SUPPLY MONITOR	784-4166
55	5.391	1	2	PB3	BATTERY SOURCE	619-0996
56	2.732	1	2	RC3	BATTERY CONVERTER	609-4511
57	1.277	4	4	PJ7	READ/WRITE SWITCH	784-4048
58	1.623	4	4	PE7	READ/WRITE DRIVER	784-3992
59	.973	8	4	PJ8	INHIBIT DRIVER	784-4050
60	1.106	1	4	PN7	WRITE DRIVER	784-4104
61	1.129	1	4	PD8	READ DRIVER	784-3980
62	.303	1	4	PD7	STROBE	784-3978
63	.808	1	4	PF7	MEMORY TIMING	784-4006
64	2.992	3	4	PE8	DIODE BOARD	784-3994
65	2.000	1	4	CORE	MAGNETIC CORE MEMORY	784-5626
66	1.097	2	4	PD5	SENSE AMPLIFIER	784-3976
67	1.727	1	4	PX2	MAJORITY CYCLE CONTROL	784-4194
68	1.476	1	4	PX5	MINORITY CYCLE CONTROL	784-4200
69	1.869	1	4	PX4	READ/SENSE CYCLE CONTR	784-4198
70	1.399	1	4	PW7	INPUT/OUTPUT CONTROL	784-4188
71	.841	1	4	PW9	INPUT/OUTPUT SELECTOR	784-4192
72	2.002	1	4	PV7	PAPER TAPE ADAPTER I	784-4174
73	1.892	1	4	PV5	PAPER TAPE ADAPTER II	784-4172
74	14.390	1	4	MTU	MAGNETIC TAPE UNIT	771-4616
76	1.838	16	4	PY5	BIT MEMORY	784-4214
78	1.599	1	4	PW8	INPUT/OUTPUT FAN-IN	784-4190
79	1.793	1	4	PY3	PANEL INTERFACE	784-4210
80	1.173	1	4	PY2	INSTRUCTION DECODER	784-4208
81	1.861	1	4	PX9	TRANSFER CONTROL A	784-4206
82	1.833	1	4	PX8	TRANSFER CONTROL Z	784-4204
83	1.734	1	4	PX7	TRANSFER CONTROL B	784-4202
84	1.744	1	4	PX3	TEST	784-4196
85	1.899	2	4	PY4	COMPARATOR ACCUMULATOR	784-4212
86	1.266	1	4	PV9	MTA SHIFT	784-4178
87	.919	1	4	PV8	MTA REGISTER	784-4176
88	1.970	1	4	PW2	MTA TIMING	784-4180
89	2.454	1	4	PW4		784-4184
90	2.592	1	4	PW5		784-4186
91	1.725	1	4	PV4	MODE CONTROL	784-4170

AN/WRR-7
O-Levels
Figure 5-4.5
(Continued)

MODEL	KEY	NUMBER	O-LEVEL	FAILURE	RATE	NUMBER	USED	WRA #	DESIG.	PART NAME	PART #
		92	2.902			1		4	LDVR	LAMP DRIVER	784-4222
		93	9.168			1		4		CHASSIS W/ MOUNTED COM	
		94	8.000			1		5	A5	RB VAPOR FREQ. REF.	617-6876
		95	1.654			1		5	A1	VOLTAGE REGULATOR	797-3632
		96	3.592			1		5	A2	SERVO AMPLIFIER	797-3632
		97	4.287			1		5	A3	SYNTHESIZER	606-9515
		98	1.134			1		5	A4	R.F. AMPLIFIER	797-3628
		99	2.802			1		5	A6	R.F. GENERATOR	606-9520
		100	2.894			1		5	A7	THERMO CONTROL	606-9527
		101	.806			1		5	A8	AUXILIARY R.F. AMP.	609-1376
		102	3.775			1		5	A9	CLOCK DIVIDER	606-9521
		103	.200			1		5	A10	BATTERY	606-9524
		104	1.090			1		5	A11	BATTERY CHARGER	606-9523
		105	3.438			1		5	A12	FTS POWER SUPPLY	606-9525

AN/WRR-7
O-Levels
Figure 5-4.5
(Continued)

```
RUN
 77/04/12. 15.58.06.
PROGRAM   WRR7

INPUT MISSION LENGTH (IN DAYS) =  ? 60

MEAN TIME BETWEEN FAILURES BY WRA (IN HOURS)
RECEIVER          POWER SUPPLY   DEMODULATOR    PROCESSOR       TIME STD.
 2938              2641            1731            772              2521

OVERALL SYSTEM MTBF =  334

OVERALL SYSTEM RELIABILITY FOR  60  DAY MISSION =  .013


SBU      0.786 UNTS.

RUN COMPLETE.
```

Figure 5-4.6

SECTION V - PROBLEMS

5-1 PROBLEM DEFINITION.

5-1.1 PROBLEM DEFINED. For the purpose of this report, a problem is defined as a module, part or assembly specified MTBF being greater the FRAP predicted mean at the 90% confidence level (the specified MTBF being below the upper 90% confidence limit). If only a single failure is observed and the specified MTBF is so large that the total accumulated sample time is not at least 20% of the specified MTBF, that single failure will not be considered a problem unless that module, part or assembly is also at least 95% significant on a structured analysis of depot data (see Section X).

5-2 AN/ART-50 PROBLEMS OBSERVED.

5-2.1 Of the 44 failures observed (37 corrective actions, some with multiple replacements), 70% involved the FTS. These 31 failures are not resolvable below WRA level because FTS repair at VQ-4 is an I-level task and the I-level facility was not included in the FRAP study. During the period of the FRAP study, the FRAP sample encompassed an estimated 80% of all operational AN/ART-50's. Therefore, depot return data for AN/ART-50 should accurately reflect FTS module level performance at VQ-4, i.e. for the FRAP sample. This data shows the Rubidium Vapor Frequency Reference (RVFR) as the highest failure module in the FTS. In the problem impact ranking (see 10-2.1 for a discussion of depot data problem ranking), five additional FTS modules (43% of those in the unit) show up as significant problems, i.e., fail significantly more often than predicted. While this might be indicative of an overly optimistic reliability prediction, it more likely indicates that the FTS design is marginal in the airborne environment.

5-2.2 The processor WRA recorded 10 failures, five of which were sent to I-level for resolution. Of these five, four are not resolvable to module level. The fifth was sent to I-level for replacement of bad switches and lights. Two non--resolvable failures listed "will not load" as the failure symptom. At the present state of resolution, no significant processor problems can be identified.

5-3 AN/WRR-7 PROBLEMS OBSERVED.

5-3.1 Of 17 failures observed (15 corrective actions with two cases of multiple replacements), four (24%) involved the FTS and seven (41%) involved the R-1738/WR radio receiver. Both WRA's met MTBF specifications. No significant problems were identified in the FTS. One significant problem, the receiver power supply module, was identified in the R-1738/WR radio. Three power supply failures plus two occasions of fuse replacement (a prelude to power supply failure) were observed. The data suggests the possibility that some of the SMO failures may be induced as secondary failures resulting from power supply degradation/failure.

SECTION VI - CORRECTIVE ACTIONS

6-1 AN/ART-50.

6-1.1 The AN/ART-50 has potential for significant reliability growth if effective corrective actions are taken. The effects of various corrective actions as illustrated in the following table.

TABLE 5-6.1

Action Taken:	No Action	Projected Maximum	Expected Maximum	FTS Fix	RVFR Only	Hot Spare
IMPROVEMENT FACTOR	1.0	2.79	1.55	1.39	1.18	2.79
EQUIPMENT MTBF (Hours)	168	469	260	234	199	417

In this table, status quo is taken as "No Action". The "Projected Maximum" assumes none of the modules listed on Table 5-10.1 has been subjected to past corrective action while "Expected Maximum" and those to the right reflect an estimate of the impact of past corrective actions. In all cases, it is assumed that any corrective action will merely restore the affected module to the originally predicted MTBF. For example, the "FTS Fix" is assumed to bring the FTS MTBF up to its predicted 1240 hour MTBF level. The "RVFR Only" fix is the current retrofit being installed. "Hot Spare" is a redundancy arrangement being fitted aboard certain aircraft. It nearly totally removes the FTS as a potential system problem (4328 hour effective MTBF on 12 hour missions) at the expense of doubling FTS module return rates. None of the corrective actions or combinations of corrective actions examined raise the MTBF to 750 hours, which indicates the current design will not reach the specified equipment MTBF. At the current level of performance, 92% of all 12 hour missions are flown without an AN/ART-50 failure. The hot spare FTS modification will mean 97.2% of such missions can be flown without system outage. For comparision, 98.2% of such missions would have been flown without repair if the AN/ART-50 performed up to the 750 hour MTBF specification. This would amount to seven additional no outage missions per year as compared to the hot spare arrangement.

6-2 AN/WRR-7.

6-2.1 The AN/WRR-7 is undergoing reliability growth at this time as evidenced by the observed failure distribution, a Weibull with a beta of 0.416. A system with a constant failure rate has a beta of 1.00, which is the familiar exponential or "constant hazard" situation usually associated with electronics hardware. It is too soon to assess the ultimate impact of current corrective actions, such as those involving the Magnetic Tape Unit (MTU), except to note that the observed growth trend must be attributed to these actions since the system has been deployed long enough to have passed beyond the "infant mortality" stage.

6-2.3 An air filter on the back of the R-1738/WR radio receiver is difficult to remove, clean, and replace. The current design is a polyfoam material without a rigid frame. Four self-locking nuts must be removed to free the assembly. Considering the physical location and the fact tools are required to remove/replace the filter, a very great disincentive exists to clean the filter regularly. Although FRAP was unable to positively document a cause/effect relationship, it is strongly suspected that filter blockage figures prominently in the accerated rate of Stable Master Oscillator (SMO) returns observed (see section 10-3.8 for discussion about the SMO). Collins has designed a slide-out rigid frame filter that can be easily serviced without tools. It is highly recommended that this assembly be made available to AN/WRR-7 users as a field-installable retrofit kit.

SECTION VII - COST BENEFIT

7-1 AN/ART-50

7-1.1 Considering the necessity of this equipment to be up during the complete 12 hour mission, the most realistic cost effective improvement appears to be the hot spare as discussed in paragraph 6-1.1 above. As the ART-50 is presently meeting its MIL-HDB-217 predicted MTBF of 169 hours (See Section 9-2), improvement of a similar magnitude by other means would be much more costly.

7-2 AN/WRR-7

7-2.1 Figure 5-7.1 shows the effort of independent improvement of maintainability, logistic and reliability on operational availability (MTBF/MTBF + MDT) of the WRR-7 This shows a similar magnitude of improvement in logistics and reliability results in the same operational availability improvement. The reliability is still improving as evidenced by failure rates following the Weibull distribution with β = .416. However, it is not expected to double the present estimated MTBF of 2432 hours. When, a pair of the WRR-7 are used, the expected system MTBF is 7296 hours, a 3-fold increase resulting in an operational availability of .956 with the present down time. Then, if the present MDT were reduced by a factor of 4, the operational availability would be .988. This reduction in down time should not be too costly as 75% of the total down time observed in the FRAP sample was due to one maintenance action (See paragraph 9-2.3).

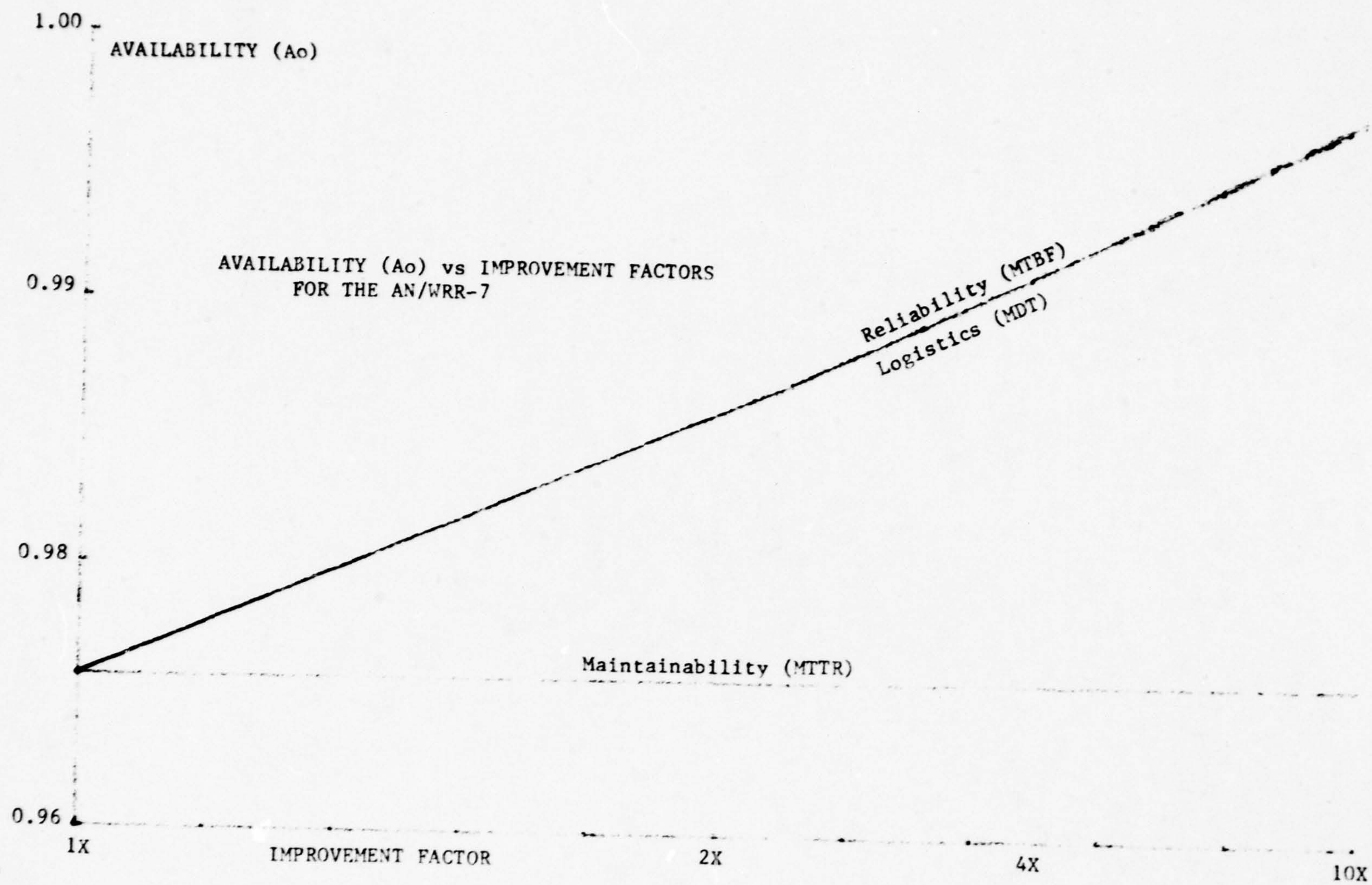

1.00
AVAILABILITY (Ao)
AVAILABILITY (Ao) vs IMPROVEMENT FACTORS
FOR THE AN/WRR-7
0.99
Reliability (MTBF)
Logistics (MDT)
0.98
Maintainability (MTTR)
0.96
1X
IMPROVEMENT FACTOR
2X
4X
10X

Figure 5-7.1

TABLE 5-7.1

AN/WRR-7 OPERATIONAL AVAILABILITY IMPROVEMENT

A_o = MTBF/MTBF + MDT

MTBF - 2432 assuming Weibull
MTTR = 2.3 assuming exponential
MDT = 336 assuming Weibull

RELIABILITY IMPROVEMENT

F_I	MTBF	MDT	A_o	U
1	2432	336	.879	.121
2	4864	336	.935	.065
4	9728	336	.967	.033
10	24,320	336	.986	.014

MAINTAINABILITY IMPROVEMENT

F_I	MTBF	MTTR	MDT	A_o	U
1	2432	2.3	336	.879	.121
2	2432	1.15	334.85	.879	.121
4	2492	.575	334.275	.879	.121
10	2432	.23	334.045	.879	.121

LOGISTIC IMPROVEMENT

F_I	MTBF	MTTR	MDT	A_o	U
1	2432	2.3	336	.879	.121
2	2432	2.3	169.15	.935	.065
4	2432	2.3	85.725	.966	.034
10	2432	2.3	35.67	.986	.014

SECTION VIII - SPECIFICATION REQUIREMENTS.

8-1 CONTRACT SPECIFICATION.

8-1.1 AN/ART-50. Air specification AS-1238B (AV), SPECIFICATION FOR RADIO GROUP AN/ARA(#), dated 6 March 1973, states in paragraph 3.3.2.3 "... 750 hours of mean (operating) time between failures..." is required. No quantitative MTTR values are called out although maintainability enhancing design features are called out.

8-1.2 AN/WRR-7. ELEX-R-119B, CONTRACT SPECIFICATION VLF/LF RADIO RECEIVING SET, DIGITAL DATA, dated 24 September 1973, states in section 3.3.9.1 "The specified mean time between failures (MTBF) (θo as defined by MIL-STD-781) of this equipment shall be 1,000 hours for the receive terminal equipment (see 1.2.1)". The "receive terminal equipment" is now nomenclatured AN/WRR-7. No quantitative MTTR values are stated although maintainability enhancing design features are called out and the requirement for an MTTR prediction in accordance with MIL-HDBK-472 is called out. The VERDIN SHIPBOARD MEAN TIME TO REPAIR PREDICTION, dated 10 February 1971, Contract Number N00039-70-C-1507, states that the predicted MTTR at O-level is 0.439 hours.

8-2 INTEGRATED LOGISTICS SUPPORT PLAN.

8-2.1 RELIABILITY. The Integrated Logistics Support Plan (ILSP), dated 9 August 1974, states, "The specified Mean Time Between Failures (MTBF) for the AN/WRR-7 receiver... is 1,000 hours. The MTBF for the AN/ART-50... is specified at 750 hours".

8-2.2 MAINTAINABILITY. The ILSP goes on to state, "The Mean Time to Repair (MTTR) value is .36 hours for A/B and .62 for S/B with organizational level maintenance limited to the replacement of failed printed circuit cards and modular assemblies". The AN/ART-50 is considered to be in the "A/B" class and the AN/WRR-7 is in the "S/B" class.

8-3 O-LEVEL SPECIFICATIONS

8-3.1 The values used for the specified O-Level requirements were basically obtained from Reliability Analysis and MTBF prediction for Verdin, Digital Data Communications System, AN/URC-62-Revision C, Volume 1, dated 9 July 1971. These failure rates are for a temperature of 50°C.

SECTION IX - FLEET DATA ANALYSIS

9-1 DATA COLLECTION.

9-1.1 Data in the FRAP field study was collected by interviews with operating and maintenance personnel (inclusive of OPNAV 4790/60 Forms from VQ-4 squadron) and by mail in the form of copies of 3M OPNAV 4790/2K forms returned using pre-addressed envelopes. To allow use of parametric analysis, FRAP instructed sample platforms to include Elapsed Time Meter (ETM) readings with each submission. Numerical data was encoded, keypunched, and statistically reduced using electronic digital computers. Data from interviews, narrative comments on the 3M forms, and information from failure analysis was used by FRAP reliability engineers to correlate, interpret and, sometimes, correct data submitted by the Fleet.

9-2 COMPUTER ANALYSIS.

9-2.1 RMA ANALYSES. These analyses and the computer output are described in Appendix C of Volume 7. Basically, the computer output consists of:

(1) Graphs for system and WRA failure and repair times and system down time showing:

a. The fit of the best-fitting probability distribution to FRAP observed times.

b. The fit of other distributions tried.

(2) Tabulation of observed data for time-to-failure, repair, and down times.

(3) Observed frequency distributions and associated goodness-of-fit tests and confidence intervals for the above parameters.

(4) Confidence intervals on the O-Level parts which failed and whether these O-Level parts are performing in the Fleet as good as specified (MIL-HDB-217 predictions).

(5) Summaries of 2K forms where problems were detected in either failure or repair times.

(6) Values for inherent and observed (predicted operational) availability.

9-2.2 SUMMARY. Table 5-9.1 summarizes the output of the computer runs for the AN/ART-50 and the AN/WRR-7 contained in Appendix 5B.

9-2.3 PARAMETER ASSESSMENT. Reliability and maintainability estimated parameters as discussed below:

(1) Reliability. From Table 5-9.1 it can be seen that the WRR-7 estimated operational MTBF exceeds the specified value of 1000 hours whereas the ART-50 estimated operational MTBF meets the predicted but does not meet the specified MTBF at the 80% confidence level. (Meeting is defined as being within the given confidence interval). However, as specifications are generally given in equipment reliability assuming the exponential distribution the effect of these two factors must be considered.

The AN/ART-50 estimated operational MTBF in the above table is for an exponential distribution. It is estimated that 89% of the failures are equipment failures (See paragraph 10-1.4) thus the estimated equipment reliability is 169 hours (150 - .89), which is still much less than the specified 750 hours. Problem areas of the ART-50 are discussed in paragraph 9-2.4 below.

The AN/WRR-7 estimated operational MTBF in the above table is for an Weibull distribution with a decreasing failure rate (β = .416). Thus the mean is changing with time and is quite variable resulting in a wide confidence interval. If the exponential is assumed, the estimated mean in 1892 hours. Then, it is estimated that 79% of the failures are equipment failures, thus the estimated equipment MTBF assuming an exponential distribution would be 2350 hours which is still much above the specified 1000 hours.

(2) Maintainability (Repair Time). The ART-50 repair time follows the Weibull distribution with a β = .707 and the WRR-7 repair time follows the exponential distribution. It can be seen in Table 5-9.1 that the lower confidence limit is much larger than the specified MTTR for the ART-50 and WRR-7, thus indicating a problem with repair time. However, all 3-M repair times are recorded to the nearest hour, including time for fault isolation, and obtaining on-board repair parts. Also, considering the medians, 50% or more of the repair times are estimated to be below two hours. The improvement of these repair times will not affect the operational availability significantly, as is shown in Section VII.

(3) Maintainability (Down Time). Down time is defined as equipment being in an inoperable or reduced capability state. By definition and mission, the AN/ART-50 is always up during its mission use. However, the down time of the AN/WRR-7 follows the Weibull distribution (β = .2364) with an estimated mean of 336 hours. However, 75% of the total down time was due to a maintenance action on one submarine. The effect of this large down time shows up in the gross difference between the median, 2.2 hours, and the mean. Nevertheless, considering the length of mission of submarines (60 days) and the effect on operational availability, it is desired to eliminate all down times of such magnitude. The effect of improvement in down time upon availability is described in Section VII.

9-2.4 PROBLEM AREAS. Problem areas will be addressed by WRA first. Module level problems will be addressed in the order of appearance in the O-level summary.

(1) AN/ART-50. At the 90% confidence level, the MTBF of WRA-5, the FTS, is not greater than 294 hours. This is nearly 1,000 hours less than the predicted 1240 hour MTBF, indicating a severe problem exists. Of the observed 44 failures, 31 involved the FTS (one of the six WRA-4 999 failures refers to an FTS replacement). This is 70% of all observed AN/ART-50 failures. Resolution of problems below WRA level is not possible because AN/ART-50 users in the FRAP sample considered FTS repair to be an I-level task. No other significant problems were identified.

(2) AN/WRR-7. All WRA's meet or exceed predictions. The only significant O-level problem is the receiver power supply module, WRA-1 10. Three failures were observed with two additional failures (fuses) being related. The power supply is known to blow fuses with increasing frequency before total failure. This problem is known to have surfaced during the FRAP study period. See Section 10-3.6 for further discussion.

TABLE 5-9.1

	ART-50	WRR-7
Total Equipment Calendar Time	5,541	64,008
Total Equipment Operating Time	25,344	28,373
Duty Cycle	.219	.443
No. of Operational Failures	37	15
Estimated Operational MTBF	150	2432
80% Confidence Interval	120-188	0-4838
Estimated Median TBF	104	351
Specified MTBF	750	1000
Predicted (MIL-HDB-217) MTBF	169	334
Estimated Operational MTTR	4.0	2.3
80% Confidence Interval	2.9-5.2	1.7-3.2
Estimated Median TTR	2.0	1.6
Specified MTTR	.36	.62
Estimated Operational MDT	-	336
80% Confidence Interval	-	0.1387
Estimated Median DT	-	2.2
Estimated Mean Operational Availability	-	.809
Estimated Inherent Availability	.974	.982
Specified Inhterent Availability	.9995	.9994

SECTION X - DEPOT DATA ANALYSIS

10-1 BACKGROUND.

10-1.1 DATA SOURCE. The AN/URC-62 family of VLF communications equipment is manufactured by Collins Radio Group, a division of Rockwell International. Depot level repair for Verdin modules and mainframes has been established at the Collins facility located in Newport Beach, California. NAVELEX has contracted with Collins Newport to provide engineering support services, one of which is a monthly report by a reliability engineer that contains, among other things, a computer data bank printout of repair actions sorted by module part number.* This report and especially the data listing is absolutely invaluable for reliability analysis. The data is timely, complete and of superior quality. Data from the March 1977 report was partitioned into AN/ART-50 and AN/WRR-7 returns. Non-flying AN/ART-50 users and non-shipboard AN/WRR-7 users were removed from the data base. AN/URT-30 returns were likewise screened out. The partitioned repair actions were then tabulated by part number in preparation for statistical analysis.

10-1.2 STRUCTURED ANALYSIS. FRAP has developed a failure ranking technique useful for locating field problems as evidenced by their module return rates. This method takes into account both the numbers of each module used in a system and the complexity of each module. A problem is evidenced by an observed return rate which is significantly larger than the expected return rate. To measure this significance, a Poisson Test of Means is used. The results of this test are expressed in percent and represent the probability that the observed return rates are greater than the expected return rates. In FRAP, 95% or greater probability (significance) was used as the trigger point for follow-up study.

10-1.3 Additional calculations were performed for those modules identified as having 95% + significance from structured anlaysis. Using the projected expected return rate, a calculation was performed as to the percentage of reduction in the overall return rate that would have resulted had the module demonstrated the predicted MTBF. This reduction is the maximum that can reasonably be expected of this design.

10-1.4 VERIFICATION RATIO. To assist in problem isolation, a verification factor for each 95% + significant module was calculated using:

$$V = (N_1 + N_2/2)/N$$

where N_1 = Number of failures confirmed at depot
N_2 = Number of non-confirmed failures
$N = N_1 + N_2$ = Total number of failures reported by fleet

This equation states that there is an even chance that a non-confirmed failure did malfunction in the Fleet but the cause was not discovered at depot level repair.

* "Monthly Report for Verdin Field Failure Monitoring Program", data item C00J on contract N00039-75-0082.

This is perhaps somewhat harsh on the depot test facility, but depot tests are in open air at room temperature with no vibration and usually on simulation jigs. Even if the trouble report specifically calls out a temperature problem, as did the SMO module serial number 360 which returned to depot on 25 May 1976 with this trouble report, "SMO OUT OF LOCK LITE WAS ON AT 50 DEG C AND GREATER THAN 90 PERCENT RH. AFTER COOLING DOWN, LITE WENT OFF", the trouble often (as in this case) is not confirmed. A verification ratio of 0.85-0.90 (20-30% unconfirmed) is considered average. The possible values range from 0.50 for no confirmations to 1.00 for all returns confirmed as failures. Some types of possible problems that will result in low verification ratios are: Errors in tech manuals, BITE design faults, misapplications, thermal or vibration problems, and correlation problems between module test jigs and actual system operating conditions.

10-2 FINDINGS FOR AN/ART-50.

10-2.1 AN/ART-50. A total of 158 modules from AN/ART-50 users were tabulated and statistically analyzed. Seven modules indicated a 95% + significance. They will be reviewed in the order of projected maximum improvement, i.e., the ranking order of Table 5-10.1. This ranking indicates the areas of greatest potential system improvement. It does not address cost effectiveness nor technical feasibility.

10-2.2 MAGNETIC TAPE UNIT (MTU). The MTU, part number 771-4616-001, was a severe early problem in the Verdin Processor. The module is a reel-to-reel digital tape recorder using two servoed motors to maintain constant tape speed and tension without using a capstan. These motors drive the takeup reels via flat belts. The entire assembly is enclosed such that no access to the mechanics or electronics of the unit is possible without tools. The MTU shows 100% significance on 42 returns with a verification ratio of 0.88. Early units suffered from two problems that were related. At humidities of 40% or more, the tape became sticky and adhered to the tape guides and record/playback head. This added load plus a small slipping problem overloaded the drive motor shaft/belt interface resulting in rapid wear of the motor shaft friction coating. Once the coating was gone, the motors could not start the tape fast enough to allow data transfer. A change in the tape, a different shaft coating, and changes in the tape guides have removed those problems. The effect of these severe problems remain in the depot data and will continue to remain for some time. This is further accented by a much smaller problem concerning the unexpectly high incidence of connector damage. MTU's must be removed from non-ready status aircraft because the tape contains classified data. This results in more handling damage than was projected. Changes in installation procedures have reduced the rate of connector breakage. It is not yet possible to assess the effect of these changes on the depot return rate.

10-2.3 RUBIDIUM VAPOR FREQUENCY REFERENCE (RVFR). The RVFR, part number 617-6876-001, is the heart module of the FTS. It contains a lamp/filter arrangement which shines light through a gas cell of rubidium vapor. This gas cell is contained in a

microwave cavity. When microwave energy of a precise frequency (6.834833 GHz) is present, electrons in the upper ground state are induced to drop into the lower ground state, a transition that emits a photon of microwave energy. Filtered light optically pumps the lower ground state to the high energy state, from which electrons fall with equal probability into the two ground states. The pumping process absorbs light in proportion to the number of electrons pumped. With microwave energy of the correct frequency present, the number of pumped electrons roughly doubles. A photocell detects the resulting drop in light transmission as the microwave energy hits the precisely correct pumping frequency. From this effect an error voltage is created that controls the FTS. The RVFR module shows 100% significance on 25 returns with a verficiation ratio of 0.98. The FTS was designed with the intent that it be fully powered at all times. In aircraft operation, the FTS is powered down after each flight. The RVFR stripline microcircuit is being literally torn apart by thermal stress during ON-OFF cycling. ECP's to address this problem have been developed and are being implemented. No reworked RVFR modules were in service during the FRAP study.

10-2.4 MAGNETIC CORE MEMORY. The core module, part number 784-5626-001, is a part of the processor and, like the MTU, is removed from non-ready status aircraft for security reasons. Like the MTU, the core module is suffering primarily from handling damage. The core module contains an array of tiny wires strung with doughnuts (cores) of ferrite material such that a non-volatile computer memory is formed. The core stack shows 100% significance on 11 returns with a verification ratio of 0.88, which is average. This indicates that the BITE testing of this complex module is effective. Like the MTU, new handling/installation procedures have been implemented to reduce physical damage. It is not yet possible to assess the effect of these procedures on depot return rates.

10-2.5 R.F. GENERATOR. The radio frequency generator, part number 606-9520-001, is part of the FTS. The generator is a 10 MHz crystal controlled oscillator. The error signal mentioned in the RVFR discussion is applied to this assembly. A varactor diode, which is a voltage controlled capacitor, slightly alters the output frequency in response to the error signal to hold the generator precisely on 10 MHz. The generator module shows 100% significance on 9 returns with a 0.91 verification ratio. No pattern of failure is apparent. From the verification ratio, it appears that the module is not being returned by mistake, but is actually failing to perform in the field.

10-2.6 FTS POWER SUPPLY. The FTS power supply module, part number 606-9525-001, was an early problem. An electrolytic filter capacitor materials problem was identified and corrected. Modules in the field with the problem capacitor are handled on a replace-while-repaired basis. This module shows 99.96% significance on 9 returns with a verification ratio of 1.00.

10-2.7 SYNTHESIZER. The synthesizer module, part number 606-9515-001, is part of the FTS. It receives the 10 MHz generated by the R.F. generator and creates the various output frequencies of the FTS. It also creates the mixing frequency which forms the basis for the microwave excitation energy applied to the RVFR gas cell. Synthesizer modules show 100% significance on 6 returns with a verification ratio of 1.00. No pattern of failure is apparent.

10-2.8 RB2 MODULE. The RB2 module, part number 784-3659-001, is a -5.2V power supply. It shows 99.92% significance on 7 returns with a verification ratio of 0.93. The RB2 module was an early problem corrected by parts changes, specifically

Q1 through Q5. Modules in the field are handled on a replace-while-repaired basis. Usually the reason for return of the RB2 module is the failure of the parts which are to be retrofitted.

10-3 <u>FINDINGS FOR AN/WRR-7.</u>

10-3.1 AN/WRR-7. A total of 561 modules from AN/WRR-7 users were tabulated and statistically analyzed. Fifteen modules indicated a 95% + significance. They will be reivewed in the order of projected maximum improvement, i.e. the ranking order of Table 5-10.2. This ranking indicates the areas of greatest potential improvement and does not address cost effectiveness or technical feasibility. Since many Verdin modules are used throughout the family, certain modules are used in the AN/ART-50 and are discussed in detail there. Such modules will include a reference to the appropriate section of the AN/ART-50 analysis as part of their discussion.

10-3.2 RB2 MODULE. The RB2 module, part number 784-3659-001, is a part of the Verdin power supply. It shows 100% significance on 50 returns with a verfiication ratio of 1.00. See Section 10-2.8 for discussion.

10-3.3 BFO/AUDIO MODULE. The Beat Frequency Oscillator/audio module, part number 616-1760-001, is a part of the R-1738/WR radio receiver. This module is a tuning aid for the operator. It contains an oscillator which may be manually adjusted to produce an audio tone by heterodyning (beating) against the received signal as output from the I.F. amplifier. Such an arrangement can also be used to receive continuous wave (C.W.) hand-keyed Morse Code transmissions. The module is tested during system self test, but the BFO adjustment knob must be set at a rotational extreme or invalid indications will result. The BFO/audio module shows 100% significance on 38 returns with a verification of 0.70, which indicates a factor other than component failure is operating. It is concluded that the Fleet users believe significant ECP action has been enacted on the BFO/audio module and that they should return their modules for rework and updating. Once the module supply turns over so that all are updated, this "problem" is expected to go away.

10-3.4 RUBIDIUM VAPOR FREQUENCY REFERENCE. The RVFR module, part number 617-6870-001, is a part of the FTS. This module shows 100% significance on 50 returns with a verification ratio of 0.98. Refer to section 10-2.3 for discussion.

10-3.5 FTS POWER SUPPLY. The FTS power supply module, part number 6-6-9525-001, shows 100% significance on 23 returns with a verification ratio of 0.98. See Section 10-2.6 for discussion.

10-3.6 R-1738/WR RECEIVER POWER SUPPLY. The power supply module, part number 616-1789-001, is a part of the R-1738/WR radio set. This module shows a 100% significance on 23 returns with a verification ratio of 0.96. The return rate, triple the 7 returns expected, and the high verification ratio indicate an equipment problem exists in the module. This problem developed during the FRAP study period and first became significant on depot data with the January 1977 report when it showed 97.18% significance. The trend indicates the problem is still developing and no estimate of its severity is possible from depot data. Collins has identified two failure patterns which are likely to be interrelated. The power transformer, T1, is failing, probably

due to overload from failing electrolytic filter capacitors. These capacitors have been identified as being overloaded with regard to AC ripple current. At the time this module was designed, no ripple current specifications had been developed for the capacitor used. An ECP is being prepared at this time.

10-3.7 PW5 MODULE. The PW5 module, part number 784-4186-001, is the magnetic tape interface for the processor. Class 1 ECP No. 282R2 recalled this module for a retrofit to avoid MTU lockup when a power drop occurs during rewinding of the MTU's tape. The verification ratio of 0.52, nearly the lowest possible, shows that most of the 23 returns were sent back for modification rather than repair.

10-3.8 STABLE MASTER OSCILLATOR. The SMO module, part number 792-6701-001, is part of the R-1738/WR radio receiver. This large, complex module contains 28% of the total circuitry in the R-1738/WR radio set. In the SMO, a 5 MHz reference signal is used to control the generation of the various heterodyne frequencies needed by the radio for its operation. The SMO can either accept an external 5 MHz signal from a source such as the FTS or create its own 5 MHz reference from a stabilized internal crystal oscillator. The SMO is 99.86% significant on 30 returns (17 were expected) with a verification ratio of 0.93, which indicates that the reason for return is actual part failure.

10-3.9 MAGNETIC CORE MEMORY. The core module, part number 784-5626-001, is a part of the processor. This module contains an array of fine wires with tiny ferrite doughnuts (cores) strung on them like beads. This array is a non-volatile computer memory for the processor. The core module shows 100% significance on 15 returns with a verification ratio of 0.86. Further, 6 of the 13 returns are for mechanical damage to covers and connectors, clearly a handling related problem. The returns situation resembles the experience of the AN/ART-50 users except that their verification ratio (0.88) is higher. AN/WRR-7 users have their systems in a secure area and have no need to pull and replace MTU's and core stacks as do airborne Verdin users. The reason for the similarity between the shipboard and airborne user's experience with regard to handling damage is unknown.

10-3.10 SECOND INTERMEDIATE FREQUENCY AMPLIFIER. The 2nd I.F. amp module, part number 616-1829-001, is a part of the R1738/WR radio set. The 2nd I.F. amplifier module contains Noise Reduction Circuits (NRC) and crystal bandwidth filters in addition to fixed gain amplifier stages. This module shows 100% significance on 12 returns with a verification ratio of 0.86. The verification ratio is in the expected range of 0.85-0.90, which indicates that these modules are being returned for cause. No failure pattern is apparent.

10-3.11 PW9 MODULE. The PW9 module, part number 784-4196-001, is a part of processor. It is also called a "fan-in selector", which means it serves to select which of several inputs will pass into the processor. This module is 100% significant on 9 returns with a verification ratio of 0.63. The very low verification ratio and the fact that all reasons for return as listed by the users were "repair" indicates that a problem exists in the system test procedure. The users had no symptoms to report which means either that the auto diagnotics called the module out as faulty or, more likely, the user suspected the module and could not prove it to be definitely good or definitely defective.

10-3.12 FREQUENCY SHIFT KEY DETECTOR. The FSK detector module, part number 616-1730-001, is part of the R-1738/WR radio set. This module receives the output of the 2nd I.F. amp and converts it into a single channel 6V polar keyed data stream suitable for teletype use. The FSK detector module shows a significance of 99.59% on 8 returns with a verification ratio of 0.75. Three of the returns showed mechanical damage; none of the returns required electronic parts replacement. Confirmed failures appear to be of the type expected under normal wear and tear.

10-3.13 R.F. AMPLIFIER. The radio frequency amplifier, part number 797-3628-001, is part of the FTS. This module amplifies and filters the outputs of the synthesizer module, and originates the TIMING FAULT lamp signal. The R.F. amplifier module shows a 99.81% significance on 8 returns with a verification ratio of 0.94, which indicates that the unit is being returned for cause. No failure pattern is apparent.

10-3.14 RADIO FREQUENCY GENERATOR. The R.F. generator is part of the FTS. It is 98.09% significant on 11 returns with a verification factor of 0.80. See Section 10-2.5 for discussion.

10-3.15 PK9 MODULE. The PK9 module, part number 784-4066-001, is part of the demodulator. Also known as the amplitude multiplier, the PK9 module is part of the analog signal processing circuitry. This module shows 99.05% significance on 6 returns with a verification ratio of 0.80. No failure pattern is apparent. No descriptive symptoms were reported.

10-3.16 PF7 MODULE. The PF7 module, part number 784-4006-001, is part of the processor. Also known as the memory timing module, PF7 works with the core stack to provide the processor a non-volite memory. This module shows 98.06% significance on 5 returns with a verification ratio of 0.80. In 3 cases delay line, designator DL1, was replaced. There were no descriptive symptoms accompanying the returns.

10-4 CONCLUSIONS FROM DEPOT DATA.

10-4.1 AN/ART-50. The single largest problem area is the FTS with 57% of the significant problems listed in Table 5-10.1. It is estimated that the operational MTBF of the system could be raised 29% to 194 hours by bringing the FTS into line with its predicted reliability performance. The number of FTS modules with significant problems probably indicates that the current FTS design is marginal in the airborne environment.

10-4.2 AN/WRR-7. The R-1738/WR radio set is the largest current system problem area. The presence of 5 modules on the significant problem listing might be taken as an indication that the R-1738/WR is being operated independently of the remainder of the system and is accumulating a disproportionate number of hours. The SMO and 2nd I.F. amp modules show good verification ratios with no pattern of failures. The power supply and FSK detector modules show patterns which account for their accelerated return rates. The BFO/audio module appears to be a special case not related to operating time. This is not to rule out the possiblity that the radio set is run while the processor and so forth are shut down. The support for such a theory, however, is not present in this depot data.

10-4.3 VERIFICATION RATIOS. Verification ratios (V) and number (N) on which it is based by system are as follows:

TABLE 5-10.3

SORT:	AN/ART-50	AN/WRR-7	All Verdin
N	147	341	743
V	0.80	0.79	0.83

To determine the impact of the lack of Fleet user input on the effectiveness of depot repairs, the following tabulation was made:

TABLE 5-10.4

SORT:	Returns w/o Symptoms	Returns w/Symptoms
N	534	209
V	0.80	0.88

It appears that depot repair effectiveness can be increased by including a description of trouble symptoms with the returned module.

RESULTS OF AN/ART-50 DEPOT ANALYSIS

	NAME	PART NO.	FAILURES Observed	FAILURES Expected	% Improvement Possible	% Significant	Action Status	Verification Factor
1	MTU	771-4616	42	6	23	100.00	Yes	.88
2	RVFR	617-6876	25	2	15	100.00	Yes	0.98
3	Mag. Core	784-5626	11	1	6	100.00	No	0.91
4	RF Gen	606-9520	9	1	6	100.00	No	0.88
5	FTS P.S.	606-9525	9	3	4	99.96	Yes	1.00
6	Synthesizer	606-9515	6	1	4	100.00	No	1.00
7	RB2	784-3659	7	2	4	99.92	Yes	0.93

TOTAL 58%

TABLE 5-10.1

RESULTS OF AN/WRR-7 DEPOT ANALYSIS

	NAME	PART NO.	FAILURES Observed	FAILURES Expected	% Improvement Possible	% Significant	Action Status	Verification Factor
1	RB2	784-3659	50	7	8	100.00	Yes	1.00
2	BFO/Audio	616-1760	38	1	7	100.00	No	0.70
3	RVFR	617-6876	50	15	6	100.00	Yes	0.98
4	FTS P.S.	6-6-9525	23	7	3	100.00	Yes	0.98
5	RCVR P.S.	616-1789	23	7	3	100.00	Yes	0.96
6	PW5	784-4186	23	5	3	100.00	Yes	0.52
7	SMO	792-6701	30	17	2	99.86	No	0.93
8	Magnetic Core	784-5626	15	4	2	100.00	No	0.86
9	2nd IF	616-1829	12	2	2	100.00	No	0.83
10	PW9	784-4196	9	2	1	100.00	No	0.63
11	FSK Det.	616-1730	8	3	1	99.59	No	0.75
12	RF Amp	797-3628	8	3	1	99.84	No	0.94
13	RF Gen	606-9520	11	6	1	98.09	No	0.80
14	PK9	784-4066	6	1	1	99.05	No	0.80
15	PF7	784-4006	5	2	1	98.06	No	0.80

TOTAL 42%

TABLE 5-10.2

APPENDIX 5A

RELIABILITY MODEL COMPUTER PROGRAMS

```
 77/03/14. 09.16.21.
PROGRAM   ART50

100 REM MODEL FOR AN/ART-50
00105 PRINT
00110 PRINT"INPUT MISSION LENGTH (IN HOURS) = ";
00120 INPUT T
00125 PRINT
00130 DIM R(108,2),W(5)                          'SETUP ARRAYS
00140 FOR I=1 TO 5
00150 W(5)=0                                     'ZERO WRA ARRAY
00155 R=1
00160 NEXT I
00170 F0=0                                       'ZERO TOTALIZER VARIABLE
00180 RESTORE
00190 FOR I=1 TO 108
00200 READ A,B,C,D                               'READ FAILURE RATE DATA
00210 R(I,1)=B*C*1E-5                            'CONVERT TO DECIMAL
00220 R(I,2)=D
00230 IF D=0 THEN 250
00240 W(D)=W(D)+R(I,1)                           'SUM BY WRA
00250 F0=F0+R(I,1)                               'SUM FOR SYSTEM
00251 REM PLACE DISTRIBUTION BELOW
00252 R1=EXP(-(R(I,1)*T))                        'CALC SYSTEM REL.
00255 R=R*R1
00260 NEXT I
00270 REM EXPONENTIAL DISTRIBUTION IS ASSUMED
00280 FOR I=1 TO 5
00290 W(I)=1/W(I)                                'CALC. WRA MTBF
00300 W(I)=INT(W(I))                             'CROP FOR PRINTOUT
00310 NEXT I
00320 M=INT(1/F0)                                'CALC. SYSTEM MTBF
00330 PRINT"MEAN TIME BETWEEN FAILURES BY WRA (IN HOURS)"
00340 PRINT"MODULATOR","POWER SUPPLY","CONTROL BOX","PROCESSOR";
00350 PRINT,"TIME STD."
00360 PRINT W(1),W(2),W(3),W(4),W(5)
00370 PRINT
00380 PRINT"OVERALL SYSTEM MTBF = ";M
00390 REM OVERAL SYSTEM RELIABILITY IS IN R
00400 PRINT
00410 PRINT"OVERALL SYSTEM RELIABILITY FOR ";T;" HOUR MISSION = ";
00420 R=INT(1000*R)/1000                         'CROP FOR PRINTOUT
00430 PRINT R
00440 PRINT
00450 STOP
00460 REM O-LEVEL FAILURE RATES (IN %/1000 HOURS)
00470 REM R#, FAILURE RATE, NUMBER USED, WRA KEY NUMBER
00480 DATA    1,  2.642, 1, 2
00490 DATA    2,  2.208, 3, 2
00500 DATA    3,  2.052, 2, 2
00510 DATA    4,  4.491, 3, 2
00520 DATA    5,  5.611, 1, 2
00530 DATA    6,  2.411, 1, 2
00540 DATA    7,  2.060, 1, 2
```

Figure 5-A.1

```
00550 DATA    8, 11.787, 1, 2
00560 DATA    9,  3.471, 1, 2
00570 DATA   10,  6.486, 1, 2
00580 DATA   11,  3.095, 1, 3
00590 DATA   12,  4.053, 1, 3
00600 DATA   13,  4.490, 1, 3
00610 DATA   14,  3.394, 1, 3
00620 DATA   15,  3.390, 1, 3
00630 DATA   16,  5.533, 2, 3
00640 DATA   17,  6.463, 1, 3
00650 DATA   18,  7.146, 1, 3
00660 DATA   19,  2.889, 1, 3
00670 DATA   20,  3.799, 1, 3
00680 DATA   21,  7.261, 1, 3
00690 DATA   22,  3.428, 1, 3
00700 DATA   23,  3.498, 1, 3
00710 DATA   24,  5.284, 1, 3
00720 DATA   25,  5.574, 1, 3
00730 DATA   26,  6.382, 1, 3
00740 DATA   27, 17.202, 1, 3
00750 DATA   28,  3.735, 1, 1
00760 DATA   29,  4.259, 1, 1
00770 DATA   30,  3.853, 1, 1
00780 DATA   31,  3.788, 1, 1
00790 DATA   32,  4.153, 1, 1
00800 DATA   33,  4.318, 1, 1
00810 DATA   34,  1.756, 1, 1
00820 DATA   35,  1.838, 1, 1
00830 DATA   36,  2.881, 1, 1
00840 DATA   37, 25.498, 1, 1
00850 DATA   38, 11.786, 1, 1
00860 DATA   42,  2.411, 1, 1
00870 DATA   40,  3.297, 1, 1
00880 DATA   41,  2.834, 1, 1
00890 DATA   42,  2.411, 1, 2
00900 DATA   43,  2.052, 1, 1
00910 DATA   44,  3.471, 1, 1
00920 DATA   45,  6.518, 1, 1
00930 DATA   46,  4.491, 4, 1
00940 DATA   47,  0     , 0, 0
00950 DATA   48,  0     , 0, 0
00960 DATA   49,  0     , 0, 0
00970 DATA   50,  0     , 0, 0
00980 DATA   51,  0     , 0, 0
00990 DATA   52,  0     , 0, 0
01000 DATA   53,  0     , 0, 0
01010 DATA   54,  0     , 0, 0
01020 DATA   55,  0     , 0, 0
01030 DATA   56,  0     , 0, 0
01040 DATA   57,  2.298, 4, 4
01050 DATA   58,  5.657, 4, 4
01060 DATA   59,  2.468, 8, 4
01070 DATA   60,  3.154, 1, 4
01080 DATA   61,  3.159, 1, 4
01090 DATA   62,  1.008, 1, 4
01100 DATA   63,  1.515, 1, 4
01110 DATA   64,  2.657, 3, 4
01120 DATA   65,  2.000, 1, 4
01130 DATA   66,  1.886, 2, 4
01140 DATA   67,  3.509, 1, 4
01150 DATA   68,  3.099, 1, 4
01160 DATA   69,  3.758, 1, 4
01170 DATA   70,  2.887, 1, 4
01180 DATA   71,  1.711, 1, 4
01190 DATA   72,  3.656, 1, 4
01200 DATA   73,  3.789, 1, 4
01210 DATA   74,  1.985, 1, 4
01220 DATA   75,  0     , 0, 0
01230 DATA   76,  3.828,16, 4
01240 DATA   77,  0     , 0, 0
01250 DATA   78,  3.190, 1, 4
01260 DATA   79,  3.735, 1, 4
01270 DATA   80,  2.435, 1, 4
01280 DATA   81,  3.806, 1, 4
01290 DATA   82,  3.799, 1, 4
01300 DATA   83,  3.586, 1, 4
01310 DATA   84,  3.616, 1, 4
01320 DATA   85,  3.968, 2, 4
01330 DATA   86,  2.592, 1, 4
01340 DATA   87,  1.887, 1, 4
01350 DATA   88,  3.990, 1, 4
01360 DATA   89,  4.900, 1, 4
01370 DATA   90,  4.993, 1, 4
01380 DATA   91,  3.219, 1, 4
01390 DATA   92,  5.033, 1, 4
01400 DATA   93, 26.645, 1, 4
01410 DATA   94,  8.000, 1, 5
01420 DATA   95,  7.484, 1, 5
01430 DATA   96,  7.235, 1, 5
01440 DATA   97,  1.182, 1, 5
01450 DATA   98,  6.395, 1, 5
01460 DATA   99,  1.136, 1, 5
01470 DATA  100,  6.675, 1, 5
01480 DATA  101,  3.926, 1, 5
01490 DATA  102,  8.106, 1, 5
01500 DATA  103,  0.400, 1, 5
01510 DATA  104,  4.238, 1, 5
01520 DATA  105, 11.197, 1, 5
01530 DATA  106,  3.311, 1, 5
01540 DATA  107,  3.981, 1, 5
01550 DATA  108,  7.383, 1, 5
READY.
```

Figure 5-A.1 (Continued)

```
LIST
 77/04/12. 15.58.51.
PROGRAM   WRR7

100 REM MODEL FOR AN/WRR-7
00105 PRINT
00110 PRINT"INPUT MISSION LENGTH (IN DAYS) = ";
00115 INPUT T
00120 T=T*24
00125 PRINT
00130 DIM R(108,2),W(5)                          'SETUP ARRAYS
00140 FOR I=1 TO 5
00150 W(5)=0                                     'ZERO WRA ARRAY
00155 R=1
00160 NEXT I
00170 F0=0                                       'ZERO TOTALIZER VARIABLE
00180 RESTORE
00190 FOR I=1 TO 108
00200 READ A$,B$,C$,B,C,D
00210 R(I,1)=B*C*1E-5                            'CONVERT TO DECIMAL
00220 R(I,2)=D
00230 IF D=0 THEN 250
00240 W(D)=W(D)+R(I,1)                           'SUM BY WRA
00250 F0=F0+R(I,1)                               'SUM FOR SYSTEM
00251 REM PLACE DISTRIBUTION BELOW
00252 R1=EXP(-(R(I,1)*T))                        'CALC SYSTEM REL.
00253 REM EXPONENTIAL DISTRIBUTION IS ASSUMED
00255 R=R*R1
00260 NEXT I
00280 FOR I=1 TO 5
00290 W(I)=1/W(I)                                'CALC. WRA MTBF
00300 W(I)=INT(W(I))                             'CROP FOR PRINTOUT
00310 NEXT I
00320 M=INT(1/F0)                                'CALC. SYSTEM MTBF
00330 PRINT"MEAN TIME BETWEEN FAILURES BY WRA (IN HOURS)"
00340 PRINT"RECEIVER","POWER SUPPLY","DEMODULATOR","PROCESSOR";
00350 PRINT,"TIME STD."
00360 PRINT W(1),W(2),W(3),W(4),W(5)
00370 PRINT
00380 PRINT"OVERALL SYSTEM MTBF = ";M
00390 REM OVERAL SYSTEM RELIABILITY IS IN R
00400 PRINT
00410 PRINT"OVERALL SYSTEM RELIABILITY FOR ";T/24;" DAY MISSION = ";
00420 R=INT(1000*R)/1000                         'CROP FOR PRINTOUT
00430 PRINT R
00440 PRINT
00450 STOP
```

Figure 5-A.2

```
00460 REM O-LEVEL FAILURE RATES (IN %/1000 HOURS)
00470 REM DESIG., NAME, P/N, # USED, FAILURE RATE, WRA KEY #
05000 DATA "A2","R.F.  AMPLIFIER","616-1629",1,5.571,1
05001 DATA "A3","FIRST MIXER","616-1669",1,1.180,1
05002 DATA "A4","FIRST I.F. AMPLIFIER","616-1689",1,0.990,1
05003 DATA "A11","SECOND MIXER","616-1710",1,0.724,1
05004 DATA "A9","FSK DETECTOR","616-1730",1,1.323,1
05005 DATA "A19","7.5 KHZ AMPLIFIER","616-1740",1,0.405,1
05006 DATA "A7","5 MHZ SWITCH/AMPLIFIER","616-1749",1,0.376,1
05007 DATA "A12","BFO/AUDIO","616-1760",1,0.101,1
05008 DATA "A10","AGC DETECTOR/AMPLIFIER","616-1770",1,0.718,1
05009 DATA "A8","RECEIVER POWER SUPPLY","616-1789",1,3.706,1
05010 DATA "A1","FRONT PANEL","616-1651",1,1.618,1
05011 DATA "","CHASSIS COMPONENTS","792-6377",1,3.345,1
05012 DATA "A13","SELF CHECK MULTIPLEXER","616-1810",1,0.593,1
05013 DATA "A14","SELF CHECK","616-1820",1,0.937,1
05014 DATA "A5","SECOND I.F. AMPLIFIER","616-1829",1,1.813,1
05015 DATA "","BCD FREQUENCY CONTROL","616-1780",1,1.520,1
05016 DATA "","RFI ASSEMBLY","616-1624",1,0.490,1
05017 DATA "A6","STABILIZED MASTER OSC.","792-6701",1,8.625,1
05018 DATA "TTY","TELETYPE INTERFACE","784-5336",1,1.573,3
05019 DATA "BANL","BLACK ANALOG INTERFACE","784-5338",1,1.682,3
05020 DATA "KGEN","KEY GENERATOR INTERFACE","784-5340",1,2.532,3
05021 DATA "BDIG","BLACK DIGITAL INTERFACE","784-6444",1,2.075,3
05022 DATA "","WIRED BACKCAP ASSEMBLY","784-7611",1,1.291,3
05023 DATA "","BACKPLANE","784-5244",1,0.331,3
05024 DATA "PD9","WEIGHTING FUNCTION GENERATOR","784-3982",2,2.209,3
05025 DATA "PF9","TIME BASE I","784-4010",1,1.686,3
05026 DATA "PG2","TIME BASE II","784-4012",1,1.763,3
05027 DATA "PG3","TIME BASE III","784-4014",1,1.698,3
05028 DATA "PJ9","ADC CONTROL","784-4052",1,1.592,3
05029 DATA "PK2","ADC DETECTOR","784-4054",1,1.665,3
05030 DATA "PK3","ADC MULTIPLEXER","784-4056",1,2.127,3
05031 DATA "PK4","DIGITAL-ANALOG CONVERTER","784-4058",1,1.120,3
05032 DATA "PK5","BINARY AND TIMING","784-4060",1,2.743,3
05033 DATA "PK7","DETECTOR B","784-4062",2,1.969,3
05034 DATA "PK8","SYNCHRONIZING","784-4064",1,1.314,3
05035 DATA "PK9","AMPLITUDE MULTIPLIER","784-4066",1,0.940,3
05036 DATA "PL2","DETECTOR A","784-4068",1,1.969,3
05037 DATA "PL3","RESOLVER","784-4070",2,2.209,3
05038 DATA "","","",0,0,0
05039 DATA "PL7","REGISTER TWO","784-4076",1,2.112,3
05040 DATA "PL8","REGISTER THREE","784-4078",1,2.030,3
05041 DATA "PL9","REGISTER FOUR","784-4080",1,1.909,3
05042 DATA "PM2","REGISTER FIVE","784-4082",1,1.904,3
05043 DATA "PM3","REGISTER SIX","784-4084",1,2.043,3
```

Figure 5-A.2 (Continued)

```
05044 DATA "PM4","REGISTER SEVEN","784-4086",1,2.772,3
05045 DATA "PM5","ALARM PHASE TWO","784-4088",1,2.267,3
05046 DATA "RB7","CONTROL PHASE TWO","784-5334",1,1.833,3
05047 DATA "RA5","POWER SUPPLY, -25V","784-3655",1,2.234,2
05048 DATA "RA7","POWER SUPPLY, +15V","784-3656",3,1.593,2
05049 DATA "RA8","15 V FILTER","784-3657",2,1.751,2
05050 DATA "RA9","LAMP DRIVER","784-3658",4,3.141,2
05051 DATA "RB2","POWER SUPPLY, -5.2V","784-3659",1,3.454,2
05052 DATA "RB4","POWER SUPPLY, +25V","784-3661",1,1.947,2
05053 DATA "PV2","POWER SUPPLY MONITOR","784-4166",1,1.255,2
05054 DATA "PB3","BATTERY SOURCE","619-0996",1,5.391,2
05055 DATA "RC3","BATTERY CONVERTER","609-4511",1,2.732,2
05056 DATA "PJ7","READ/WRITE SWITCH","784-4048",4,1.277,4
05057 DATA "PE7","READ/WRITE DRIVER","784-3992",4,1.623,4
05058 DATA "PJ8","INHIBIT DRIVER","784-4050",8,0.973,4
05059 DATA "PN7","WRITE DRIVER","784-4104",1,1.106,4
05060 DATA "PD8","READ DRIVER","784-3980",1,1.129,4
05061 DATA "PD7","STROBE","784-3978",1,0.303,4
05062 DATA "PF7","MEMORY TIMING","784-4006",1,0.808,4
05063 DATA "PE8","DIODE BOARD","784-3994",3,2.992,4
05064 DATA "CORE","MAGNETIC CORE MEMORY","784-5626",1,2.0,4
05065 DATA "PD5","SENSE AMPLIFIER","784-3976",2,1.097,4
05066 DATA "PX2","MAJORITY CYCLE CONTROL","784-4194",1,1.727,4
05067 DATA "PX5","MINORITY CYCLE CONTROL","784-4200",1,1.476,4
05068 DATA "PX4","READ/SENSE CYCLE CONTROL","784-4198",1,1.869,4
05069 DATA "PW7","INPUT/OUTPUT CONTROL","784-4188",1,1.399,4
05070 DATA "PW9","INPUT/OUTPUT SELECTOR","784-4192",1,0.841,4
05071 DATA "PV7","PAPER TAPE ADAPTER I","784-4174",1,2.002,4
05072 DATA "PV5","PAPER TAPE ADAPTER II","784-4172",1,1.892,4
05073 DATA "MTU","MAGNETIC TAPE UNIT","771-4616",1,14.390,4
05074 DATA "","","",0,0,0
05075 DATA "PY5","BIT MEMORY","784-4214",16,1.838,4
05076 DATA "","","",0,0,0
05077 DATA "PW8","INPUT/OUTPUT FAN-IN","784-4190",1,1.599,4
05078 DATA "PY3","PANEL INTERFACE","784-4210",1,1.793,4
05079 DATA "PY2","INSTRUCTION DECODER","784-4208",1,1.173,4
05080 DATA "PX9","TRANSFER CONTROL A","784-4206",1,1.861,4
05081 DATA "PX8","TRANSFER CONTROL Z","784-4204",1,1.833,4
05082 DATA "PX7","TRANSFER CONTROL B","784-4202",1,1.734,4
05083 DATA "PX3","TEST","784-4196",1,1.744,4
05084 DATA "PY4","COMPARATOR ACCUMULATOR","784-4212",2,1.899,4
05085 DATA "PV9","MTA SHIFT","784-4178",1,1.266,4
05086 DATA "PV8","MTA REGISTER","784-4176",1,0.919,4
05087 DATA "PW2","MTA TIMING","784-4180",1,1.970,4
05088 DATA "PW4","","784-4184",1,2.454,4
```

Figure 5-A.2 (Continued)

```
05089 DATA "PW5","","784-4186",1,2.592,4
05090 DATA "PV4","MODE CONTROL","784-4170",1,1.725,4
05091 DATA "LDVR","LAMP DRIVER","784-4222",1,2.902,4
05092 DATA "","CHASSIS W/ MOUNTED COMPONENTS","",1,9.168,4
05093 DATA "A5","RB VAPOR FREQ. REF. (RVFR)","617-6876",1,8.0,5
05094 DATA "A1","VOLTAGE REGULATOR","797-3632",1,1.654,5
05095 DATA "A2","SERVO AMPLIFIER","797-3632",1,3.592,5
05096 DATA "A3","SYNTHESIZER","606-9515",1,4.287,5
05097 DATA "A4","R.F. AMPLIFIER","797-3628",1,1.134,5
05098 DATA "A6","R.F. GENERATOR","606-9520",1,2.802,5
05099 DATA "A7","THERMO CONTROL","606-9527",1,2.894,5
05100 DATA "A8","AUXILIARY R.F. AMPLIFIER","609-1376",1,0.806,5
05101 DATA "A9","CLOCK DIVIDER","606-9521",1,3.775,5
05102 DATA "A10","BATTERY","606-9524",1,0.2,5
05103 DATA "A11","BATTERY CHARGER","606-9523",1,1.090,5
05104 DATA "A12","FTS POWER SUPPLY","606-9525",1,3.438,5
05105 DATA "","CLOCK","617-6154",1,1.407,5
05106 DATA "A5A2","THERMO-ELEC. COOLER","606-9526",1,1.927,5
05107 DATA "","CHASSIS W/ MOUNTED COMPONENTS","606-9513",1,2.646,5
05108 END
```

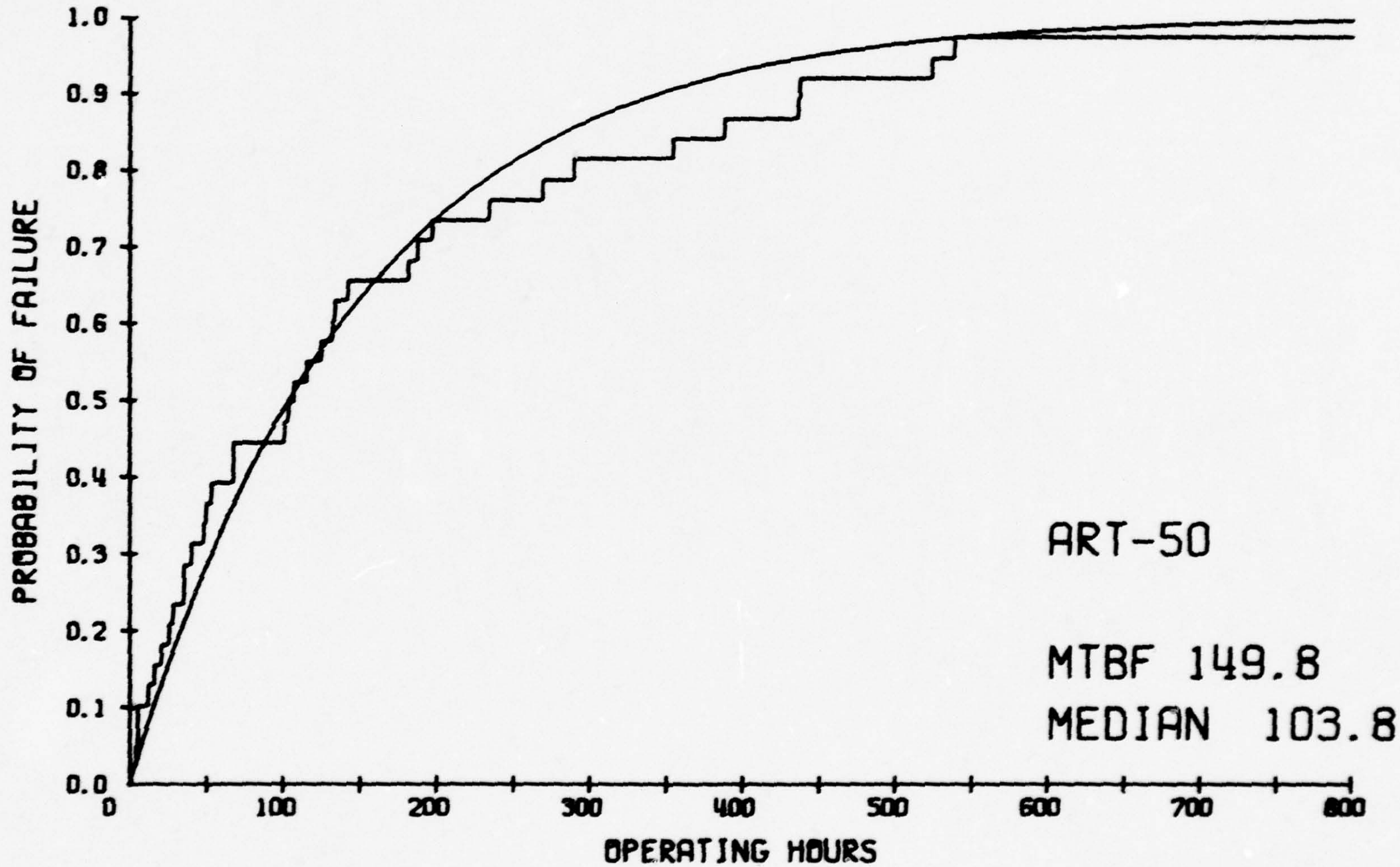
Figure 5-A.2 (Continued)

APPENDIX 5B

COMPUTER OUTPUT FOR ANALYSIS OF FRAP FLEET DATA

OUTPUT FOR AN/ART-50

CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO FAILURE



FLEET RELIABILITY ASSESSMENT DATA

MTYP	DATE	WRA	DL1	DL2	DL3	ETM	ETM1	ETM2	UPFRATE	DUTY	TTF	SYS	UIC
3	6076 6092	4	65	0	0	0.0	0.0	0.0	0.0	0.000	0.0	5	0
NO INITIAL RECORD-FIRST RECORD USED													
3	6030 6030	5	999	0	0	1766.0	1766.0	1766.0	0.0	0.000	0.0	5	151888
3	6052 6052	5	999	0	0	1878.0	1878.0	1878.0	112.0	.212	112.0	5	151888
3	6089 6090	1	999	0	0	2120.0	2120.0	2120.0	354.0	.246	242.0	5	151888
0	6258 6258	5	999	0	0	3004.0	3004.0	3004.0	0.0	0.000	0.0	5	151888
3	6310 6314	5	103	999	0	3109.0	3109.0	3109.0	105.0	.078	105.0	5	151888
3	6315 6321	4	999	0	0	3131.0	3131.0	3131.0	127.0	.084	22.0	5	151888
3	6324 6324	4	999	0	0	3172.0	3172.0	3172.0	168.0	.106	41.0	5	151888
3	7030 7030	4	999	0	0	3496.0	3496.0	3496.0	492.0	.150	324.0	5	151888
3	7031 7031	4	999	0	0	3501.0	3501.0	3501.0	497.0	.150	5.0	5	151888
3	7044 7046	5	999	0	0	3558.0	3558.0	3558.0	554.0	.151	57.0	5	151888
NO INITIAL RECORD-FIRST RECORD USED													
3	6005 6008	5	999	0	0	9834.0	9834.0	9834.0	0.0	0.000	0.0	5	151889
3	6028 6034	5	999	0	0	9839.0	9839.0	9839.0	5.0	.007	5.0	5	151889
0	6275 6275	4	74	0	0	212.0	212.0	212.0	0.0	0.000	0.0	5	151889
3	6299 6300	5	999	0	0	246.0	246.0	246.0	34.0	.057	34.0	5	151889
3	6316 6317	5	999	0	0	331.0	331.0	331.0	119.0	.118	85.0	5	151889
3	6334 6336	4	65	0	0	421.0	421.0	421.0	209.0	.143	90.0	5	151889
3	7013 7018	5	999	0	0	646.0	646.0	646.0	434.0	.167	225.0	5	151889
NO INITIAL RECORD-FIRST RECORD USED													
3	6060 6089	5	94	106	0	9922.0	9922.0	9922.0	0.0	0.000	0.0	5	156170
0	7008 7008	5	105	999	0	840.0	840.0	840.0	0.0	0.000	0.0	5	156170
3	7015 7015	5	999	0	0	870.0	870.0	870.0	30.0	.179	30.0	5	156170
3	7023 7025	5	999	0	0	900.0	900.0	900.0	60.0	.147	30.0	5	156170
NO INITIAL RECORD-FIRST RECORD USED													
3	6012 6015	5	999	0	0	9176.0	9176.0	9176.0	0.0	0.000	0.0	5	156173
3	6077 6077	1	38	0	0	9341.0	9341.0	9341.0	165.0	.106	165.0	5	156173
3	6080 6080	5	94	0	0	9359.0	9359.0	9359.0	183.0	.112	18.0	5	156173
3	6115 6115	5	999	0	0	9516.0	9516.0	9516.0	340.0	.138	157.0	5	156173
NO INITIAL RECORD-FIRST RECORD USED													
3	6144 6144	4	67	0	0	9016.0	9016.0	9016.0	0.0	0.000	0.0	5	156174
0	6299 6299	5	999	0	0	9744.0	9744.0	9744.0	0.0	0.000	0.0	5	156174
3	6331 6334	5	999	0	0	9896.0	9896.0	9896.0	152.0	.181	152.0	5	156174
NO INITIAL RECORD-FIRST RECORD USED													
3	6006 6006	4	88	0	0	9219.0	9219.0	9219.0	0.0	0.000	0.0	5	156175
3	6039 6039	5	999	0	0	9330.0	9330.0	9330.0	111.0	.140	111.0	5	156175
3	6039 6040	5	999	0	0	9331.0	9331.0	9331.0	112.0	.137	1.0	5	156175
3	6071 6074	5	999	0	0	9527.0	9527.0	9527.0	308.0	.189	196.0	5	156175
3	6089 6089	4	74	0	0	9538.0	9538.0	9538.0	319.0	.160	11.0	5	156175
NO INITIAL RECORD-FIRST RECORD USED													
3	6054 6054	2	999	0	0	8598.0	8598.0	8598.0	0.0	0.000	0.0	5	156177
3	6068 6068	1	38	0	0	8695.0	8695.0	8695.0	97.0	.289	97.0	5	156177
3	6150 6150	5	999	0	0	9060.0	9060.0	9060.0	462.0	.201	365.0	5	156177

FLEET RELIABILITY ASSESSMENT DATA

MTYP	DATE		WRA	DL1	DL2	DL3	ETM	ETM1	ETM2	OPERATE	DUTY	TTF	SYS	UIC
NO INITIAL RECORD-FIRST RECORD USED														
3	6058	6058	5	999	0	0	103.0	103.0	103.0	0.0	0.000	0.0	5	159348
0	6301	6301	4	65	0	0	1048.0	1048.0	1048.0	0.0	0.000	0.0	5	159348
3	6324	6324	4	999	0	0	1485.0	1485.0	1485.0	437.0	.792	437.0	5	159348
3	6330	6331	5	999	0	0	1509.0	1509.0	1509.0	461.0	.640	24.0	5	159348
3	6340	6342	5	999	0	0	1554.0	1554.0	1554.0	506.0	.514	45.0	5	159348
3	7043	7050	5	999	999	999	1918.0	1918.0	1918.0	870.0	.318	364.0	5	159348
NO INITIAL RECORD-FIRST RECORD USED														
3	6033	6033	5	999	0	0	109.0	109.0	109.0	0.0	0.000	0.0	5	159469
3	6122	6122	5	999	0	0	558.0	558.0	558.0	449.0	.210	449.0	5	159469
3	6149	6149	5	999	0	0	615.0	615.0	615.0	506.0	.182	57.0	5	159469
0	6224	6224	5	999	0	0	1038.0	1038.0	1038.0	0.0	0.000	0.0	5	159469
3	6259	6265	5	999	999	999	1125.0	1125.0	1125.0	87.0	.088	87.0	5	159469
3	6281	6282	4	71	74	0	1244.0	1244.0	1244.0	206.0	.148	119.0	5	159469
3	6344	6346	5	108	0	0	1540.0	1540.0	1540.0	502.0	.171	296.0	5	159469
3	6353	6353	4	59	999	0	1582.0	1582.0	1582.0	544.0	.176	42.0	5	159469
3	6355	6356	5	999	0	0	1586.0	1586.0	1586.0	548.0	.173	4.0	5	159469
3	6363	7001	5	999	0	0	1600.0	1600.0	1600.0	562.0	.165	14.0	5	159469

R E L I A B I L I T Y

ART-50 SYSTEM LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSURED	SURVIVORS	CPDF	EXPONENTIAL	MAX DIFFERENCE
1.2	1.		37.	.026	.008	.018
4.8	1.		36.	.053	.032	.021
6.0	2.		35.	.105	.039	.066
13.2	1.		33.	.132	.084	.047
16.8	1.		32.	.158	.106	.052
21.6	1.		31.	.184	.134	.050
26.4	1.		30.	.211	.162	.049
28.8	1.		29.	.237	.175	.062
36.0	2.		28.	.289	.214	.076
40.8	1.		26.	.316	.238	.077
49.2	1.		25.	.342	.280	.062
50.4	1.		24.	.368	.286	.083
54.0	1.		23.	.395	.303	.092
68.4	2.		22.	.447	.367	.081
102.0	1.		20.	.474	.494	.047
104.4	1.		19.	.500	.502	.028
108.0	1.		18.	.526	.514	.014
116.4	1.		17.	.553	.540	.014
126.0	1.		16.	.579	.569	.016
133.2	1.		15.	.605	.589	.016
134.4	1.		14.	.632	.592	.039
142.8	1.		13.	.658	.615	.043
182.4	1.		12.	.684	.704	.046
188.4	1.		11.	.711	.716	.032
198.0	1.		10.	.737	.733	.023
235.2	1.		9.	.763	.792	.055
270.0	1.		8.	.789	.835	.072
290.4	1.		7.	.816	.856	.067
355.2	1.		6.	.842	.907	.091
388.8	1.		5.	.868	.925	.083
436.8	1.		4.	.895	.946	.077
438.0	1.		3.	.921	.946	.052
524.4	1.		2.	.947	.970	.049
538.8	1.		1.	.974	.973	.025

R E L I A B I L I T Y

ART-50 SYSTEM LEVEL

EQUIPMENT OPERATING HOURS (O.H.) = 5541.6 CALENDAR HOURS(C.H.) =, 25344.0 DUTY CYCLE (O.H./C.H.) = .219

NUMBER OF FAILURES = 37. OBSERVED FAILURE RATE/O.H. = .66768E-02

DISTRIBUTION DETERMINATION,

K-S CRITICAL VALUE (.10,37.) = .158

MAX DIFF CALC = .092, IS LESS THAN CRITICAL VALUE THEREFORE THE EXPONENTIAL DISTRIBUTION IS ASSUMED

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 149.773, EST. MEDIAN = 103.815, 90 PER CENT LCL FOR MEAN = 120.3, 90 PER CENT UCL FOR MEAN = 188.1

90 PERCENT UCL 188.14 IS GREATER THAN 160.00 HOURS, THEREFORE THE EQUIPMENT MEETS THE SPECIFICATIONS

R E L I A B I L I T Y

ART-50 WRA 1 LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSORED
6.0		1.
72.0		1.
116.4	1.	
182.4		1.
198.0	1.	
210.0		1.
382.8		1.
424.8	1.	
438.0		1.
520.8		1.
607.2		1.
664.8		1.
674.4		1.
1044.0		1.

EQUIPMENT OPERATING HOURS (O.H.) = 5541.6 CALENDAR HOURS(C.H.) =, 25344.0 DUTY CYCLE (O.H./C.H.) = .219

NUMBER OF FAILURES = 3. OBSERVED FAILURE RATE/O.H. = .54136E-03

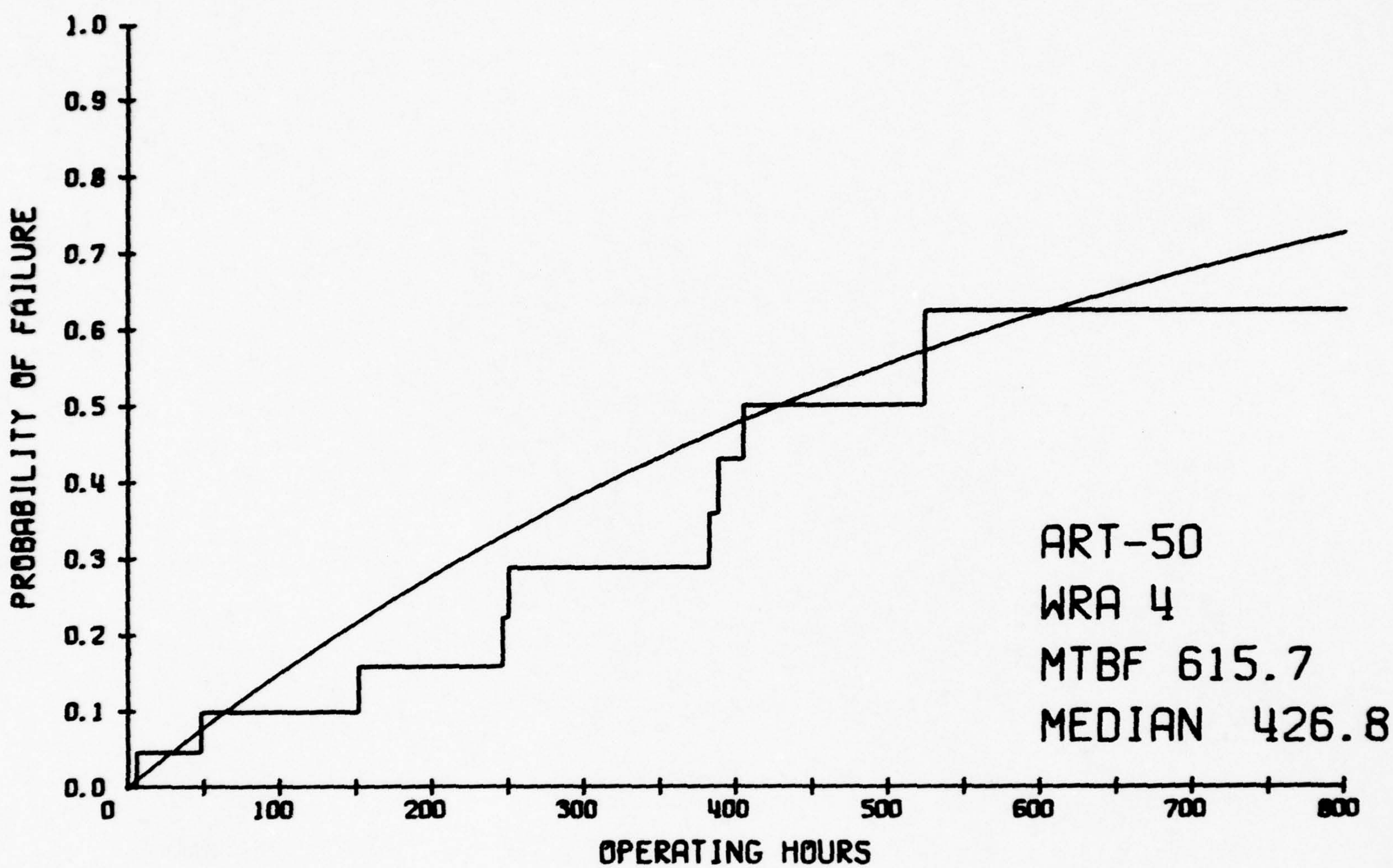
LESS THAN FOUR FAILURES THE EXPONENTIAL DISTRIBUTION IS ASSUMED

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 1847.200, EST. MEDIAN = 1280.381, 90 PER CENT LCL FOR MEAN = 829.5, 90 PER CENT UCL FOR MEAN = 5028.4

90 PERCENT UCL 5028.38 IS GREATER THAN 1306.00 HOURS, THEREFORE THE EQUIPMENT MEETS THE SPECIFICATIONS

CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO FAILURE



R E L I A B I L I T Y

ART-50 WRA 4 LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSORED	SURVIVORS	CPDF	EXPONENTIAL	MAX DIFFERENCE
6.0	1.		20.	.048	.010	.038
6.0		1.				
21.6		1.				
49.2	1.		17.	.101	.077	.029
68.4		1.				
72.0		1.				
152.4	1.		14.	.160	.219	.119
182.4		1.				
247.2	1.		12.	.225	.331	.170
250.8	1.		11.	.290	.335	.109
270.0		1.				
382.8	1.		9.	.361	.463	.173
388.8	1.		8.	.432	.468	.107
405.6	1.		7.	.503	.482	.051
408.0		1.				
424.8		1.				
519.6		1.				
524.4	1.		3.	.627	.573	.071
554.4		1.				
607.2		1.				

EQUIPMENT OPERATING HOURS (O.H.) = 5541.6 CALENDAR HOURS(C.H.) =, 25344.0 DUTY CYCLE (O.H./C.H.) = .219

NUMBER OF FAILURES = 9, OBSERVED FAILURE RATE/O.H. = .16241E-02

DISTRIBUTION DETERMINATION,

K-S CRITICAL VALUE (.10, 9.) = .311

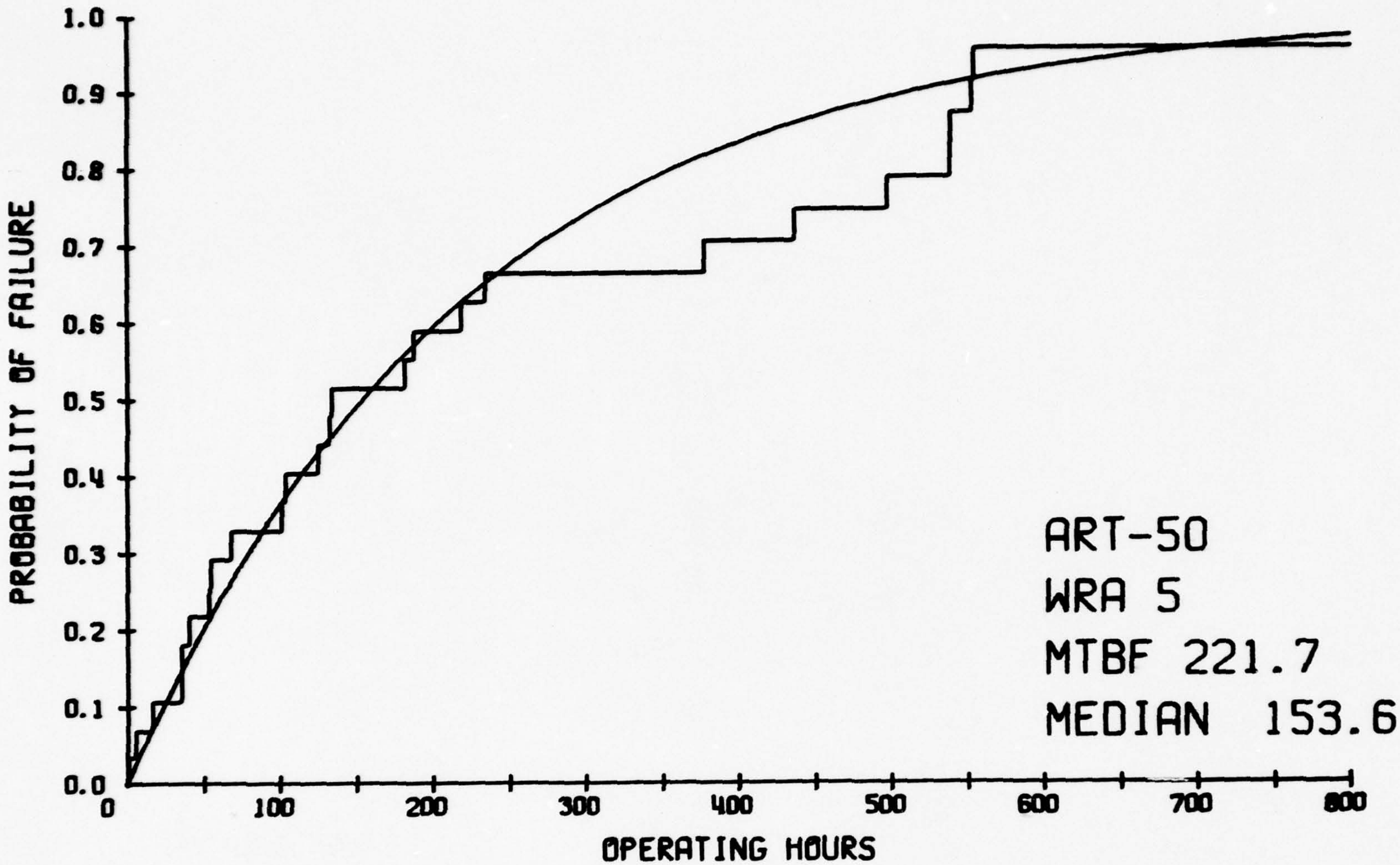
MAX DIFF CALC = .173, IS LESS THAN CRITICAL VALUE THEREFORE THE EXPONENTIAL DISTRIBUTION IS ASSUMED

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 615.733, EST. MEDIAN = 426.794, 90 PER CENT LCL FOR MEAN = 390.1, 90 PER CENT UCL FOR MEAN = 1020.1

90 PERCENT UCL 1020.09 IS GREATER THAN 407.00 HOURS, THEREFORE THE EQUIPMENT MEETS THE SPECIFICATIONS

CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO FAILURE



R E L I A B I L I T Y

ART-50 WRA 5 LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSORED	SURVIVORS	CPDF	EXPONENTIAL	MAX DIFFERENCE
1.2	1.		27.	.036	.005	.030
6.0	1.		26.	.071	.027	.045
13.2		1.				
16.8	1.		24.	.109	.073	.036
36.0	2.		23.	.183	.150	.041
40.8	1.		21.	.220	.168	.052
54.0	1.		20.	.257	.216	.041
55.2	1.		19.	.294	.220	.074
68.4	1.		18.	.331	.266	.066
102.0	1.		17.	.369	.369	.037
104.4	1.		16.	.406	.376	.030
126.0	1.		15.	.443	.434	.028
133.2	1.		14.	.480	.452	.028
134.4	1.		13.	.517	.455	.062
182.4	1.		12.	.554	.561	.044
188.4	1.		11.	.591	.573	.019
219.6	1.		10.	.629	.629	.037
235.2	1.		9.	.666	.654	.025
290.4		1.				
378.0	1.		7.	.708	.818	.153
436.8	1.		6.	.749	.861	.153
498.0	1.		5.	.791	.894	.145
538.8	2.		4.	.875	.912	.121
553.2	1.		2.	.916	.918	.043
554.4	1.		1.	.958	.918	.040

R E L I A B I L I T Y

ART-50 WRA 5 LEVEL

EQUIPMENT OPERATING HOURS (O.H.) = 5541.6 CALENDAR HOURS(C.H.) =, 25344.0 DUTY CYCLE (O.H./C.H.) = .219

NUMBER OF FAILURES = 25. OBSERVED FAILURE RATE/O.H. = .45113E-02

DISTRIBUTION DETERMINATION,

K-S CRITICAL VALUE (.10,25.) = .191

MAX DIFF CALC = .153, IS LESS THAN CRITICAL VALUE THEREFORE THE EXPONENTIAL DISTRIBUTION IS ASSUMED

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 221.664, EST. MEDIAN = 153.646, 90 PER CENT LCL FOR MEAN = 159.4, 90 PER CENT UCL FOR MEAN = 294.1

90 PERCENT UCL 294.07 IS LESS THAN 1240.00 HOURS, THUS A RELIABILITY PROBLEM EXISTS

R E L I A B I L I T Y

ART-50 O-LEVEL SUMMARY

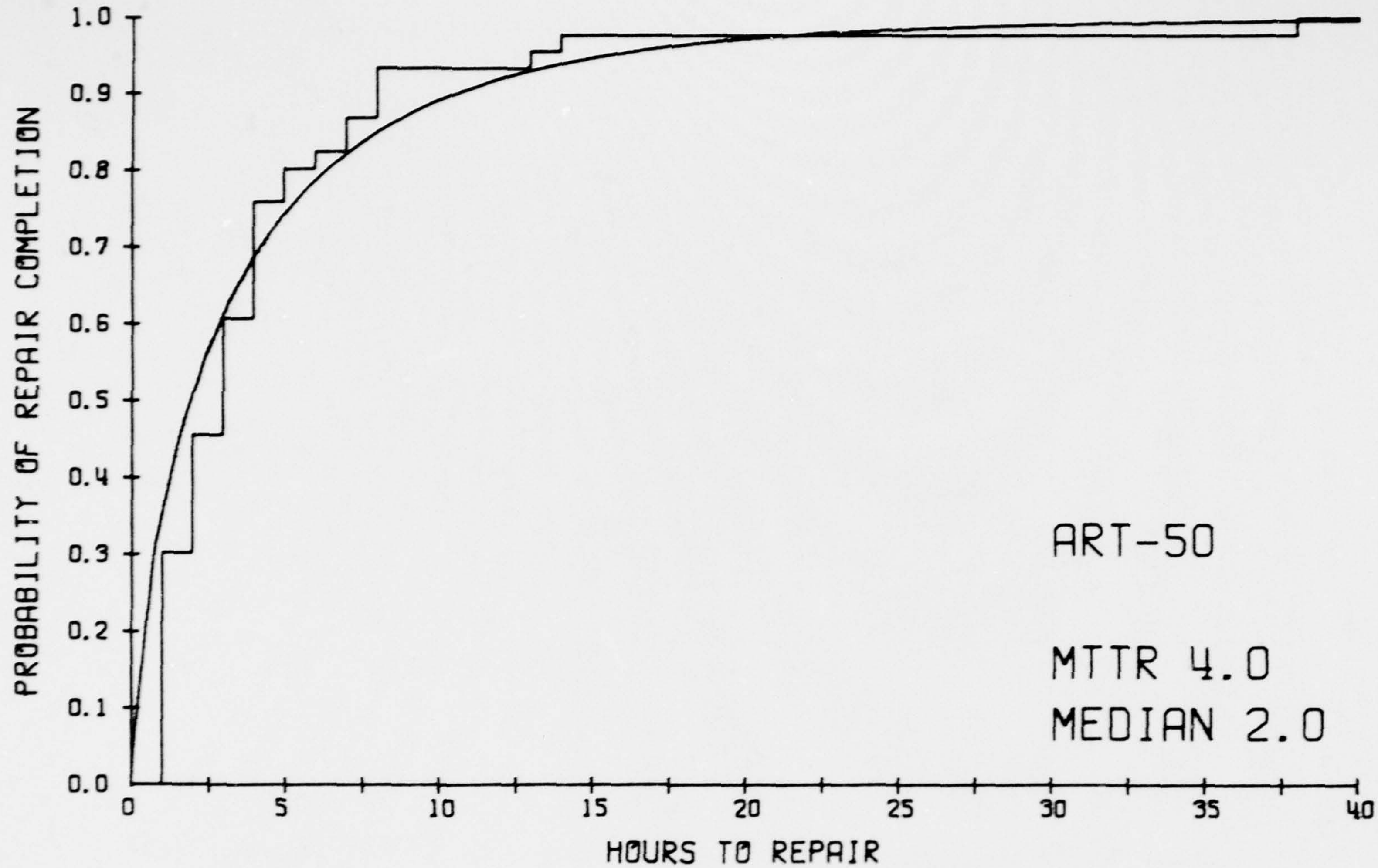
WRA	O-LEVEL BLOCK NO.		O-LEVEL NOMENCLATURE		NUMBER FAILURES	LOWER 90 CONF LIM	MEAN	UPPER 90 CONF LIM	SPEC MTBF	OBSERVED FAILURE TIMES LOW	HIGH	RELIAB PROBLEM
1	38		CHASSIS	784-7700	2.	1041.20	2770.80	10420.23	8485.00	116.40	198.00	NO
1	999				1.	1424.68	5541.60	52596.81	1000000.00	424.80	424.80	YES
4	59	PJ8	INHBT DVR	784-4050	1.	1424.68	5541.60	52596.81	5065.00	652.80	652.80	NO
4	65		CORE MAG MEM	784-5626	1.	1424.68	5541.60	52596.81	50000.00	250.80	250.80	NO
4	71	PW9	I/O SEL	784-4192	1.	1424.68	5541.60	52596.81	58445.00	247.20	247.20	YES
4	74	MTU	MAG TAPE	771-4616	2.	1041.20	2770.80	10420.23	5038.00	247.20	382.80	NO
4	999				6.	526.16	923.60	1758.18	1000000.00	6.00	652.80	YES
5	94	RVFR	FREQ REF	617-6876	1.	1424.68	5541.60	52596.81	12500.00	219.60	219.60	NO
5	103		BATTERY MODULE		1.	1424.68	5541.60	52596.81	250000.00	126.00	126.00	YES
5	108		CHASSIS		1.	1424.68	5541.60	52596.81	13545.00	602.40	602.40	NO
5	999				27.	158.55	205.24	269.03	1000000.00	1.20	664.80	YES

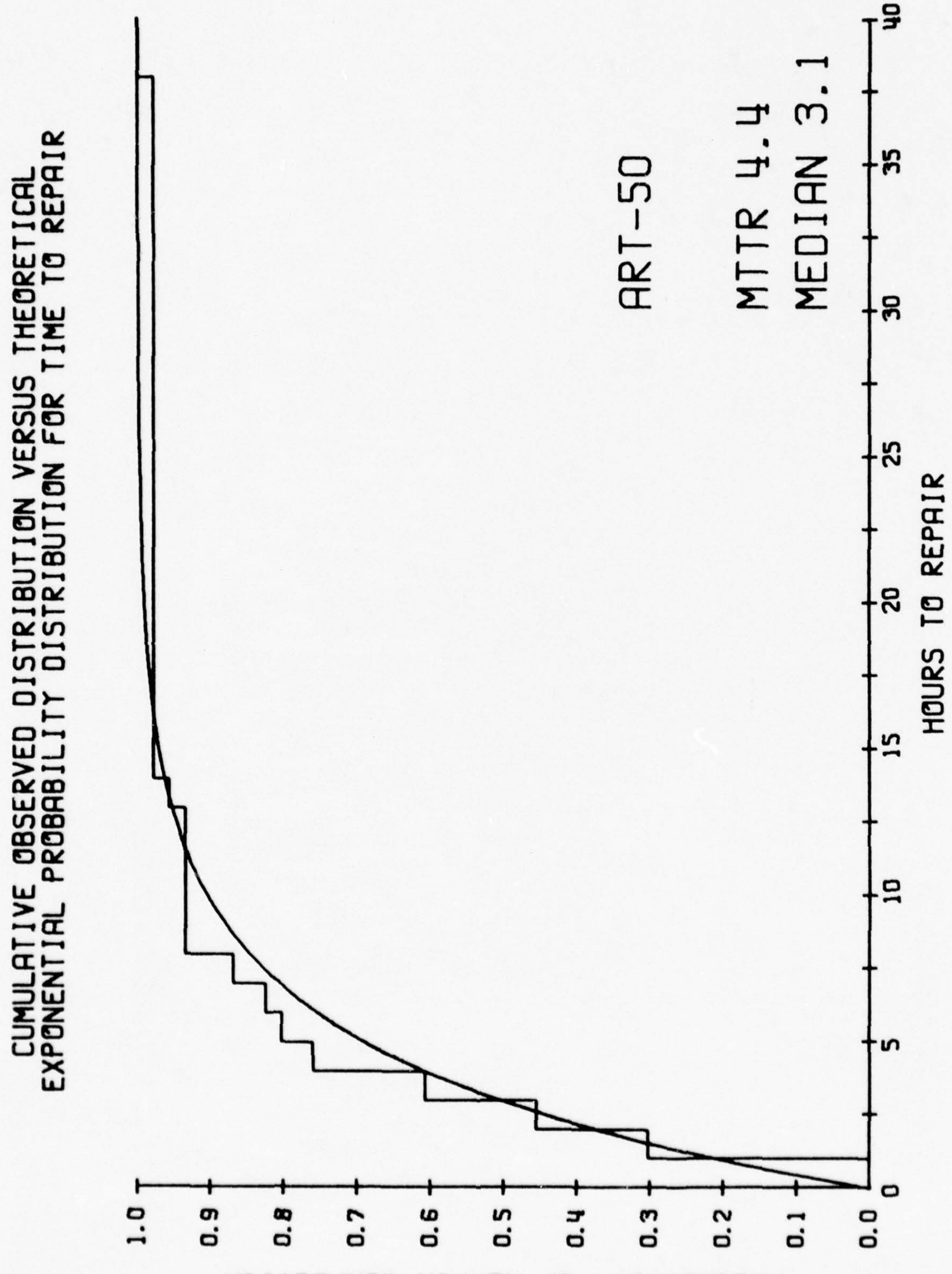
R E L I A R I L I T Y

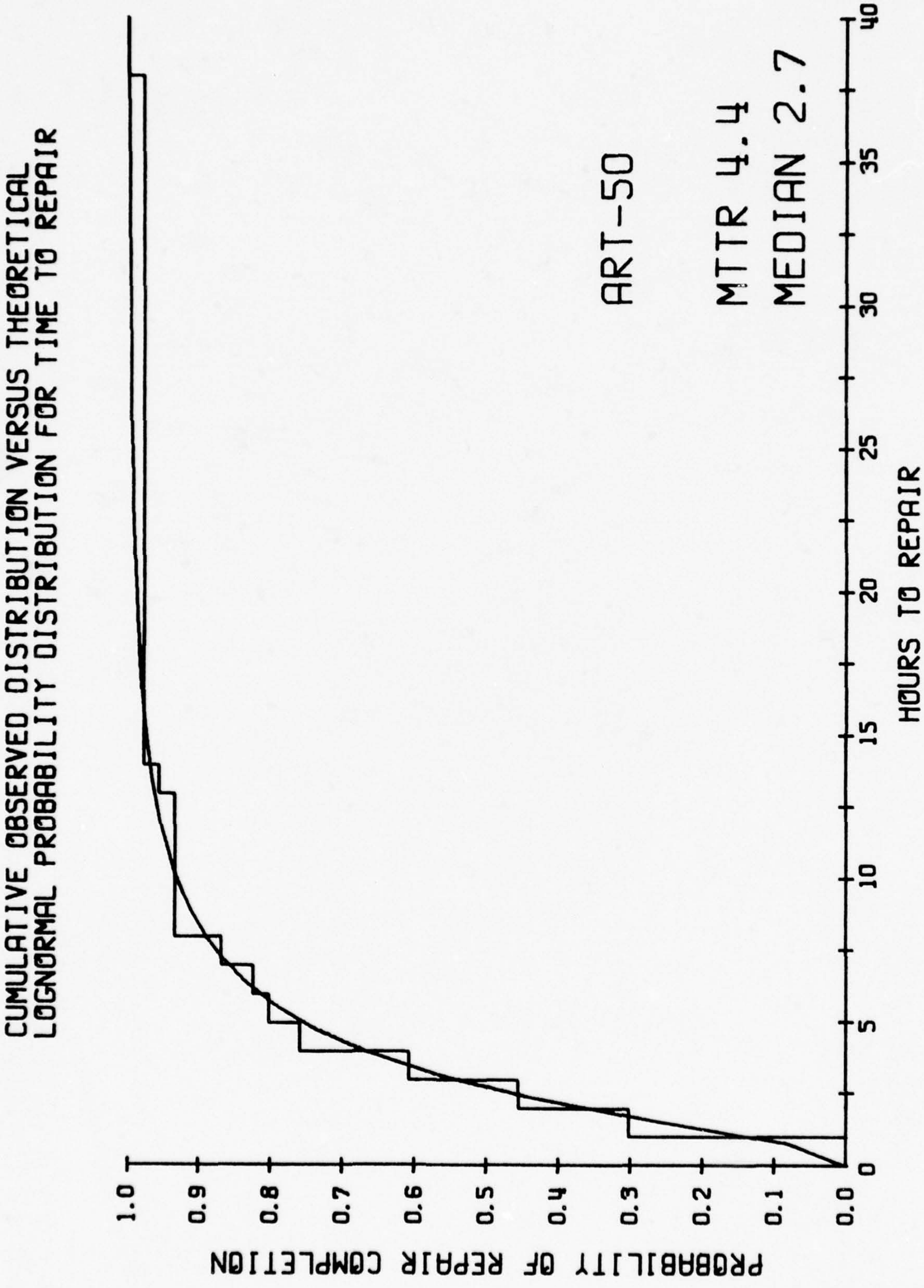
2K SUMMARY FOR ART-50 PROHLEM AREAS

JCN	SYSTEM	WRA	O-L	O-L	O-L	SYSTEM SYMPTON	DIAGNOSTIC	RESULTS
A460060308760	5	5	999	0	0	NO 2ND HARM		R+R FTS A14 W/ A21
A460060528320	5	5	999	0	0	NO TIME ON	O-SCOPE	R+R FTS A21 W/ A20
A460060808390	5	1	999	0	0	NO LITE ON1	OVISUAL	R+R BUSTED PINS
A460062588900	5	5	999	0	0	6AINS 2M/HR		R+R FTS A14 W/ A7
A460063108730	5	5	103	999	0	NO BAT OPS		R+R BAT MODULE+MOD
A460063154220	5	4	999	0	0	SWS+LITE BA	D	R+R PROCESSOR
A460063248460	5	4	999	0	0	NO PASS DIA	GMICRO	R+R PROC A2 W/ A21
A460070308730	5	4	999	0	0	NO LOAD		R+R PROC-NO FIX
A460070318740	5	4	999	0	0	NO LOAD		R+R PROC.
A460070448070	5	5	999	0	0	MISSN KNOB		R+R FTS A20 W/ A3
A460060059840	5	5	999	0	0	NO 5MHZ		R+R FTS A19 W/ A12
A460060289690	5	5	999	0	0	LOW 2ND HAR	M	R+R FTS A12 W/ A6
A460062999540	5	5	999	0	0	NO 2ND HARM	LITE	R+R FTS A11 W/ A7
A460063169440	5	5	999	0	0	BUSTED WIRE		FIX PLUG J8
A460070189210	5	5	999	0	0	TMG FAULT	LITE	R+R FTS A36 W/ A18
A460060600260	5	5	94	106	0	CAN T ALIGN	CK NO.	7R+R RVFR + CLOCK
A460070080310	5	5	105	999	0	TMG FAULT	LITE	R+R FTS A36W/ A9
A460070150660	5	5	999	0	0	TMG FAULT	LITE	ADJ + ALIGNED FTS
A460070250480	5	5	999	0	0	TMG FAULT	LITE	R+R FTS A36 W/ A9
A460060123060	5	5	999	0	0	-1MIN/2 HR	CLOCK	R+R FTS
A460060803800	5	5	94	0	0	NO TEST LIT	E	FTS TO DEPOT REPAR
A460061153600	5	5	999	0	0	NO 2ND HARM		R+R FTS A15 W/ A9
A460062994110	5	5	999	0	0	HAND STKS		R+R FTS A36 W/ A14
A460063314330	5	5	999	0	0	BUSTED CK W	R	R+R FTS A6 W/ A7
A460060395440	5	5	999	0	0	MIN HAND FZ	N	R+R FTS A7 W/ A16
A460060395470	5	5	999	0	0	NO SWX BATT	.	R+R FTS A7 W/ A16
A460060715190	5	5	999	0	0	NO 2ND HARM	TF LITE	R+R FTS A21 W/ A55
A460061507710	5	5	999	0	0	CLOCK INOP	POS = 3	R+R FTS
A460060586570	5	5	999	0	0	FAULT LITE	POS7- .	6R+R FTS A7 W/ A20
A460063246720	5	4	999	0	0	BAD MS6 PRT	29J-BUS	TR+R PROC A12/A13
A460063306950	5	5	999	0	0	NO SW TO DC		NOT CONFIRMED
A460063404080	5	5	999	0	0	FAULT LITE		R+R FTS A3 W/ A3
A460070436430	5	5	999	999	999	TMG FLT LIT	EP=7 O.	6R+R FTS A3 W/ A3
A460060331100	5	5	999	0	0	NO 5 MHZ SI	G	R+R FTS A19 W/ B6
A460061221330	5	5	999	0	0	LOW 5MHZ	POS =9	R+R FTS A36 W/ A3
A460061491250	5	5	999	0	0	SEC HND IND	PVISUAL	R+R FTS A3 W/ A9
A460062241320	5	5	999	0	0	LST 2ND HAR	M	R+R FTS A7 W/ A9
A460062581530	5	5	999	999	999	FLT LITE		R+R FTS "3 TIMES?
A460062811200	5	4	71	74	0	MTU BUST PI	N	R+R PW9 CARD MTU
A460063441500	5	5	108	0	0	BSTD PWR SW	X	R+R FTS A16 / A16
A460063531090	5	4	59	999	0	NO LOAD PGM	LITE	R+R PJ8 PCB FTS
A460063551320	5	5	999	0	0	TMG FALT LI	TLITE	ADJ 2ND HARM
A460063131550	5	5	999	0	0	TMG FAULT	LITE	R+R FTS A36W/A6

CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
WEIBULL PROBABILITY DISTRIBUTION FOR TIME TO REPAIR




CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO REPAIR
ART-50
MTTR 4.4
MEDIAN 3.1
PROBABILITY OF REPAIR COMPLETION
HOURS TO REPAIR
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
5
10
15
20
25
30
35
40


CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
LOGNORMAL PROBABILITY DISTRIBUTION FOR TIME TO REPAIR
ART-50
MTTR 4.4
MEDIAN 2.7
HOURS TO REPAIR
PROBABILITY OF REPAIR COMPLETION
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
5
10
15
20
25
30
35
40

FLEET MAINTAINABILITY ASSESSMENT DATA

WRA	DL1	DL2	DL3	DISCOVERY DATE	COMPLETION DATE	REPAIR TIME (HRS)	SYS	UIC
4	65	0	0	6076	6092	8.0	5	000000
5	999	0	0	6030	6030	8.0	5	151888
5	999	0	0	6052	6052	4.0	5	151888
1	999	0	0	6089	6090	4.0	5	151888
5	103	999	0	6310	6314	4.0	5	151888
4	999	0	0	6315	6321	4.0	5	151888
4	999	0	0	6324	6324	3.0	5	151888
4	999	0	0	7030	7030	13.0	5	151888
4	999	0	0	7031	7031	5.0	5	151888
5	999	0	0	7044	7046	2.0	5	151888
5	999	0	0	6005	6008	14.0	5	151889
5	999	0	0	6028	6034	2.0	5	151889
5	999	0	0	6299	6300	2.0	5	151889
5	999	0	0	6316	6317	3.0	5	151889
4	65	0	0	6334	6336	7.0	5	151889
5	999	0	0	7013	7018	3.0	5	151889
5	94	106	0	6060	6089	38.0	5	156170
5	999	0	0	7015	7015	1.0	5	156170
5	999	0	0	7023	7025	3.0	5	156170
5	999	0	0	6012	6015	7.0	5	156173
1	38	0	0	6077	6077	3.0	5	156173
5	94	0	0	6080	6080	4.0	5	156173
5	999	0	0	6115	6115	1.0	5	156173
4	67	0	0	6144	6144	8.0	5	156174
5	999	0	0	6331	6334	3.0	5	156174
4	88	0	0	6006	6006	6.0	5	156175
5	999	0	0	6039	6039	1.0	5	156175
5	999	0	0	6039	6040	1.0	5	156175
5	999	0	0	6071	6074	2.0	5	156175
4	76	0	0	6089	6089	4.0	5	156175
2	999	0	0	6054	6054	1.0	5	156177
1	38	0	0	6068	6068	1.0	5	156177
5	999	0	0	6150	6150	1.0	5	156177
5	999	0	0	6058	6058	1.0	5	159348
4	999	0	0	6324	6324	5.0	5	159348
5	999	0	0	6330	6331	1.0	5	159348
5	999	0	0	6340	6342	2.0	5	159348
5	999	999	999	7043	7050	3.0	5	159348
5	999	0	0	6033	6033	1.0	5	159469
5	999	0	0	6122	6122	2.0	5	159469
5	999	0	0	6149	6149	1.0	5	159469
5	999	999	999	6259	6265	4.0	5	159469
4	71	74	0	6281	6282	1.0	5	159469
5	108	0	0	6344	6346	1.0	5	159469
4	59	999	0	6353	6353	8.0	5	159469
5	999	0	0	6355	6356	2.0	5	159469
5	999	0	0	6363	7001	1.0	5	159469

MAINTAINABILITY (REPAIR TIME)

ART-50 SYSTEM LEVEL

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
1.0	14.	14.0	.298	.126	.172
2.0	7.	21.0	.447	.361	.086
3.0	7.	28.0	.596	.543	.096
4.0	7.	35.0	.745	.668	.076
5.0	2.	37.0	.787	.755	.032
6.0	1.	38.0	.809	.815	.028
7.0	2.	40.0	.851	.859	.050
8.0	3.	43.0	.915	.890	.039
13.0	1.	44.0	.936	.963	.048
14.0	1.	45.0	.957	.969	.033
38.0	1.	46.0	.979	.999	.041

TOTAL REPAIR HOURS = 204.0 NUMBER OF REPAIRS = 46. OBSERVED REPAIR RATE/HR = .2255E+00

DISTRIBUTION DETERMINATION

MEAN OF LN'S = 1.00 STD DEV OF LN'S = .88

K-S CRITICAL VALUE (.10, 46,) = .119 MAX DIFF CALC = .172 IS GREATER THAN THE CRITICAL VALUE

THEREFORE THE LOGNORMAL DISTRIBUTION CANNOT BE ASSUMED

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	EXPONENTIAL	MAX DIFFERENCE
1.0	14.	14.	.298	.202	.096
2.0	7.	21.	.447	.363	.084
3.0	7.	28.	.596	.492	.104
4.0	7.	35.	.745	.594	.150
5.0	2.	37.	.787	.676	.111
6.0	1.	38.	.809	.742	.067
7.0	2.	40.	.851	.794	.057
8.0	3.	43.	.915	.835	.080
13.0	1.	44.	.936	.947	.032
14.0	1.	45.	.957	.957	.021
38.0	1.	46.	.979	1.000	.042

TOTAL REPAIR HOURS = 204.0 NUMBER OF REPAIRS = 46. OBSERVED REPAIR RATE/HR = .2255E+00

DISTRIBUTION DETERMINATION

K-S CRITICAL VALUE (.10, 46,) = .142 MAX DIFF CALC = .150 IS GREATER THAN THE CRITICAL VALUE

THEREFORE THE EXPONENTIAL DISTRIBUTION CANNOT BE ASSUMED

WEIBULL DISTRIBUTION ASSUMED, ESTIMATED PARAMETERS ARE ALPHA = .43677E+00 BETA = .70796E+00

EST MEDIAN = 1.968 EST MEAN = 4.063 90 PER CENT LCL ON MEAN = 2.923 90 PER CENT UCL ON MEAN = 5.163

SPECIFIED MTTR = .75 HOURS LOWER CONF LIM 2.92 IS GREATER THAN MTTR, THUS A MAINTAINABILITY PROBLEM EXISTS

MAINTAINABILITY (REPAIR TIME)

ART-50 WRA 1 LEVEL

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
1.0	1.	1.0	.250	.129	.121
3.0	1.	2.0	.500	.644	.394
4.0	1.	3.0	.750	.777	.277

TOTAL REPAIR HOURS = 8.0 NUMBER OF REPAIRS = 3. OBSERVED REPAIR RATE/HR = .3750E+00

DISTRIBUTION DETERMINATION

MEAN OF LN'S = .83 STD DEV OF LN'S = .73

LESS THAN FOUR DISTINCT REPAIR TIMES

THEREFORE THE LOGNORMAL DISTRIBUTION IS ASSUMED

EST MEAN = 2.67 EST MEDIAN = 2.29 90 PER CENT LCL ON MEDIAN = 1.03 90 PER CENT UCL ON MEDIAN = 5.08

SPECIFIED MTTR = .75 HOURS LOWER CONF LIM 1.03 IS GREATER THAN MTTR, THUS A MAINTAINABILITY PROBLEM EXISTS

MAINTAINABILITY (REPAIR TIME)

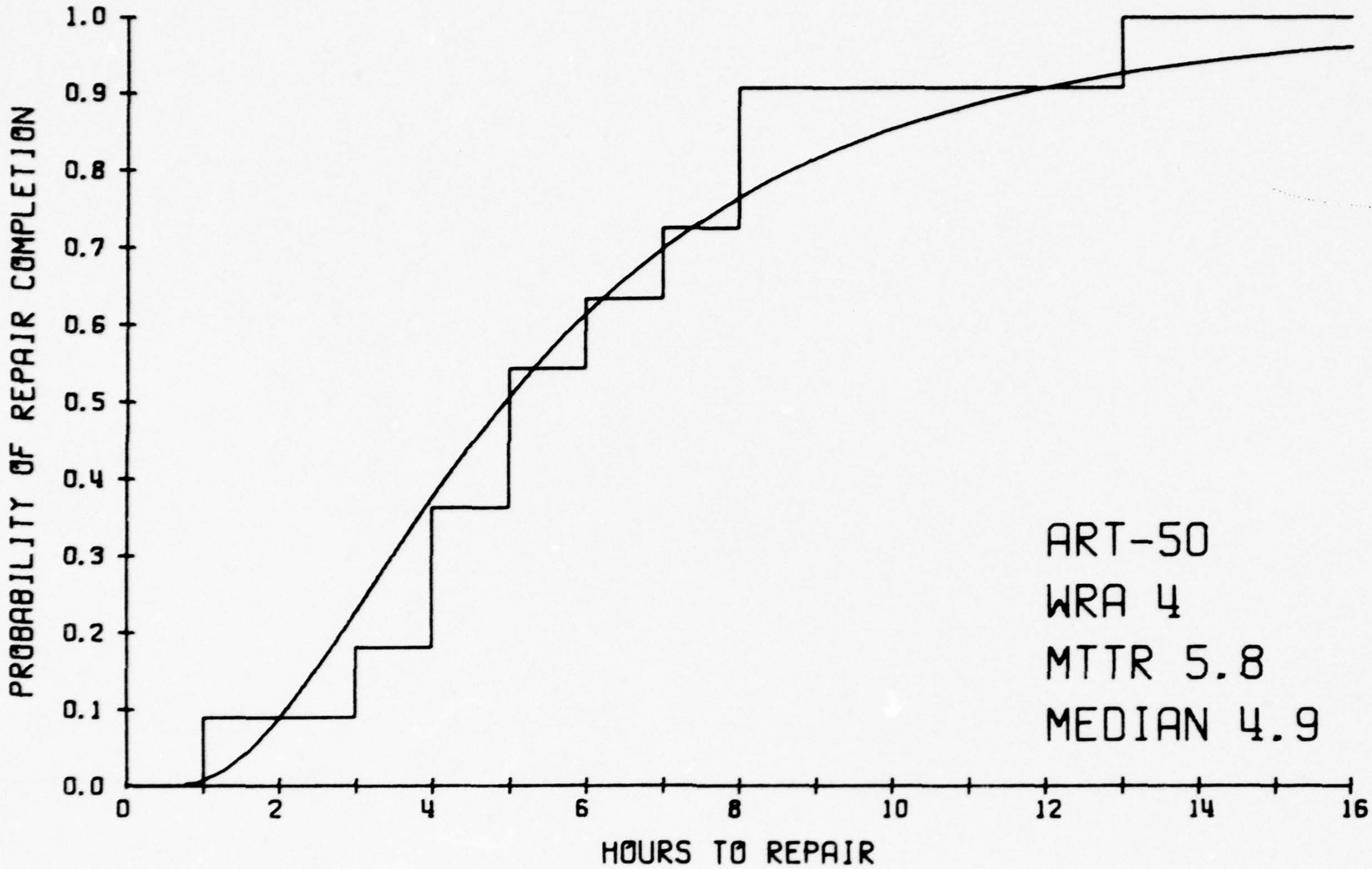
ART-50 WRA 2 LEVEL

LESS THAN FOUR DISTINCT REPAIR TIMES

THEREFORE THE LOGNORMAL DISTRIBUTION IS ASSUMED

ONLY ONE DISTINCT REPAIR TIME -- NO CONFIDENCE LIMITS

CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL LOGNORMAL PROBABILITY DISTRIBUTION FOR TIME TO REPAIR



MAINTAINABILITY (REPAIR TIME)

ART-50 WRA 4 LEVEL

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
1.0	1.	1.0	.083	.008	.075
3.0	1.	2.0	.167	.228	.145
4.0	2.	4.0	.333	.377	.210
5.0	2.	6.0	.500	.508	.175
6.0	1.	7.0	.583	.616	.116
7.0	1.	8.0	.667	.700	.117
8.0	2.	10.0	.833	.766	.099
13.0	1.	11.0	.917	.927	.094

TOTAL REPAIR HOURS = 64.0 NUMBER OF REPAIRS = 11. OBSERVED REPAIR RATE/HR = .1719E+00

DISTRIBUTION DETERMINATION

MEAN OF LN'S = 1.60 STD DEV OF LN'S = .67

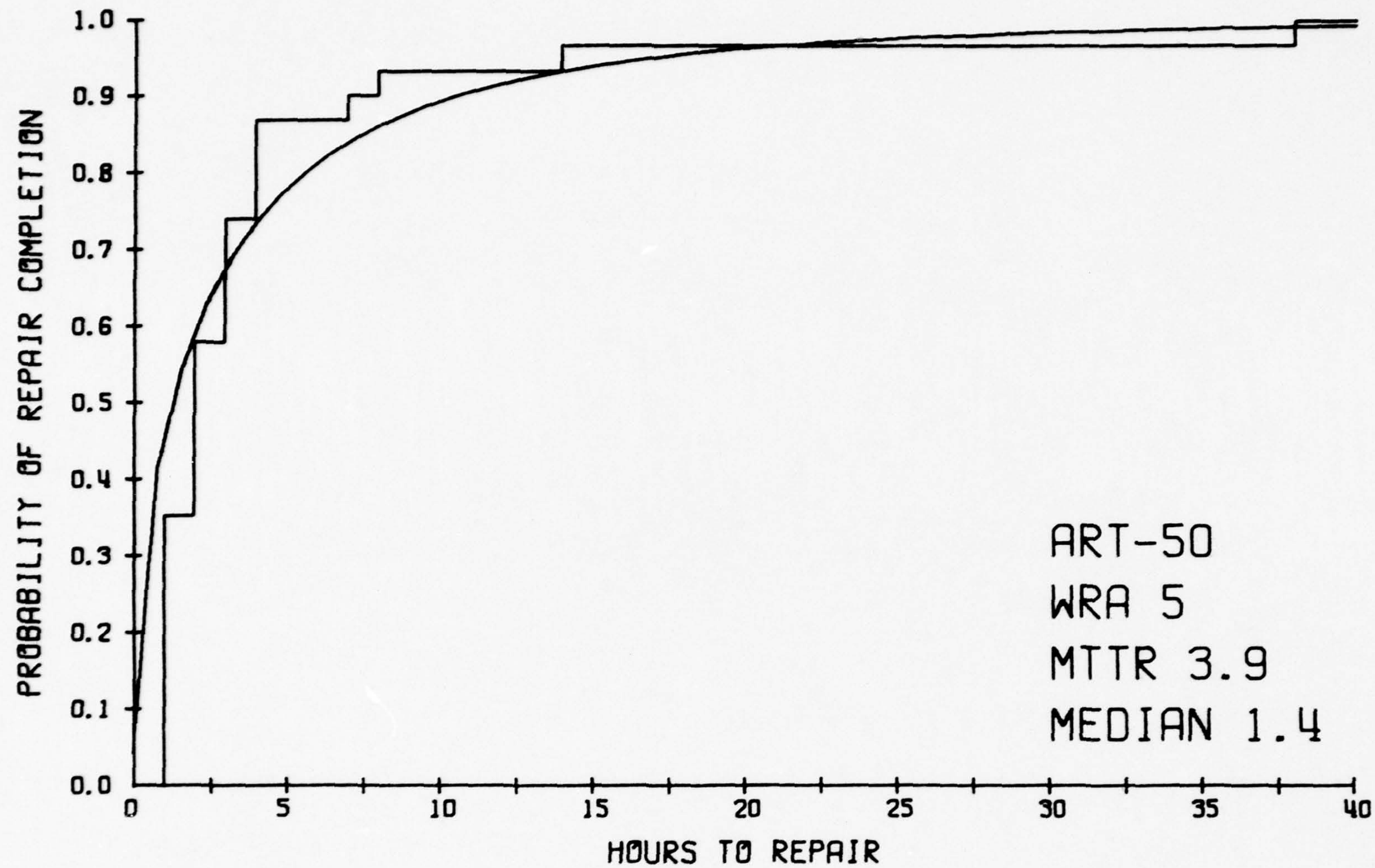
K-S CRITICAL VALUE (.10, 11.) = .230 MAX DIFF CALC = .210 IS LESS THAN THE CRITICAL VALUE

THEREFORE THE LOGNORMAL DISTRIBUTION IS ASSUMED

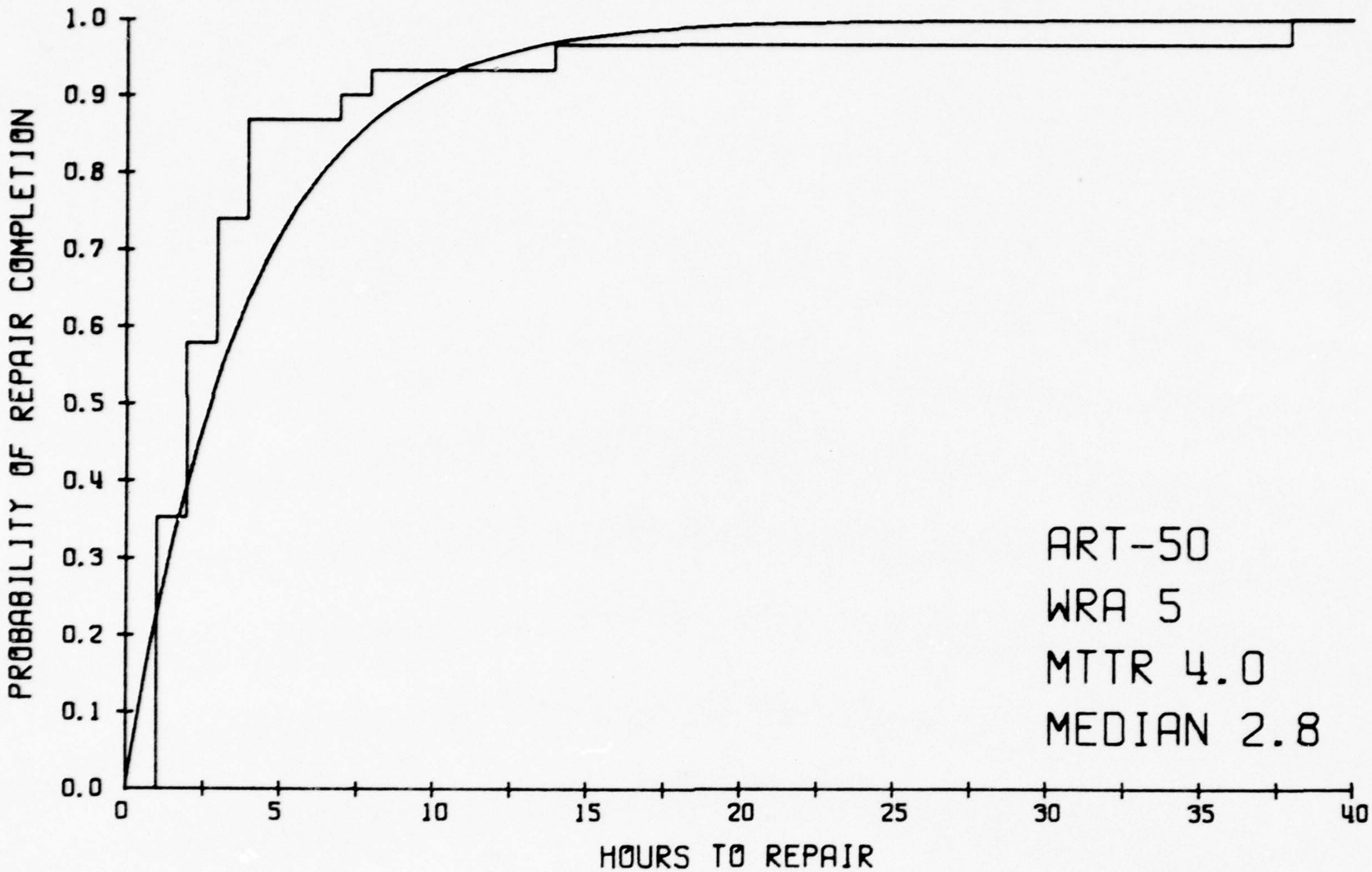
EST MEAN = 5.82 EST MEDIAN = 4.93 90 PER CENT LCL ON MEDIAN = 3.74 90 PER CENT UCL ON MEDIAN = 6.50

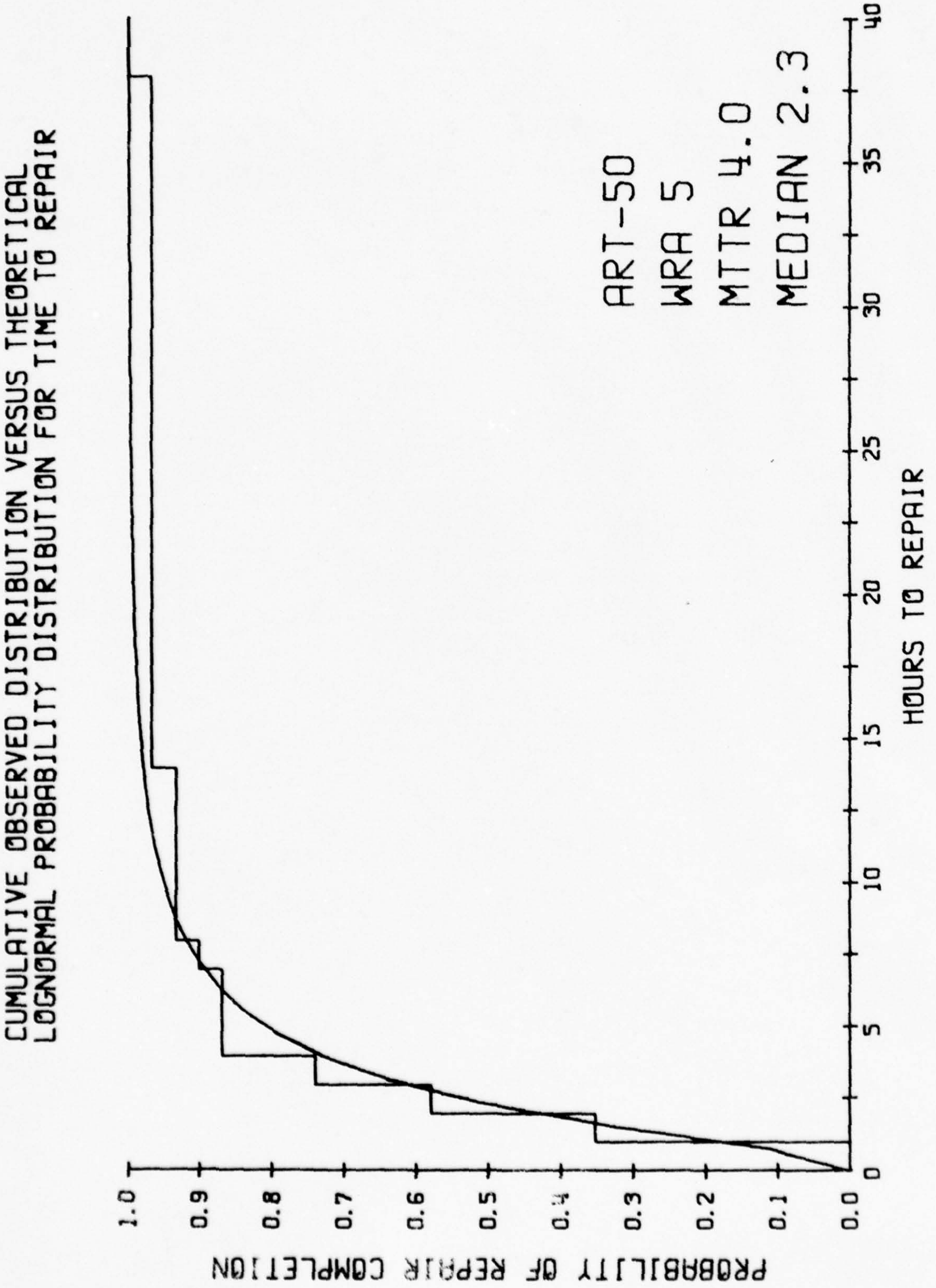
SPECIFIED MTTR = .75 HOURS LOWER CONF LIM 3.74 IS GREATER THAN MTTR, THUS A MAINTAINABILITY PROBLEM EXISTS

CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL WEIBULL PROBABILITY DISTRIBUTION FOR TIME TO REPAIR



CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO REPAIR




CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
LOGNORMAL PROBABILITY DISTRIBUTION FOR TIME TO REPAIR
ART-50
WRA 5
MTTR 4.0
MEDIAN 2.3
PROBABILITY OF REPAIR COMPLETION
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
HOURS TO REPAIR
0
5
10
15
20
25
30
35
40

MAINTAINABILITY (REPAIR TIME)

ART-50 WRA 5 LEVEL

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
1.0	11.	11.0	.344	.169	.175
2.0	7.	18.0	.563	.432	.131
3.0	5.	23.0	.719	.613	.105
4.0	4.	27.0	.844	.731	.113
7.0	1.	28.0	.875	.894	.051
8.0	1.	29.0	.906	.919	.044
14.0	1.	30.0	.938	.979	.073
38.0	1.	31.0	.969	.999	.061

TOTAL REPAIR HOURS = 123.0 NUMBER OF REPAIRS = 31. OBSERVED REPAIR RATE/HR = .2520E+00

DISTRIBUTION DETERMINATION

MEAN OF LN'S = .84 STD DEV OF LN'S = .88

K-S CRITICAL VALUE (.10, 31.) = .145 MAX DIFF CALC = .175 IS GREATER THAN THE CRITICAL VALUE

THEREFORE THE LOGNORMAL DISTRIBUTION CANNOT BE ASSUMED

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	EXPONENTIAL	MAX DIFFERENCE
1.0	11.	11.	.344	.223	.121
2.0	7.	18.	.563	.396	.167
3.0	5.	23.	.719	.531	.188
4.0	4.	27.	.844	.635	.209
7.0	1.	28.	.875	.829	.046
8.0	1.	29.	.906	.867	.039
14.0	1.	30.	.938	.971	.064
38.0	1.	31.	.969	1.000	.062

TOTAL REPAIR HOURS = 123.0 NUMBER OF REPAIRS = 31. OBSERVED REPAIR RATE/HR = .2520E+00

DISTRIBUTION DETERMINATION

K-S CRITICAL VALUE (.10, 31.) = .172 MAX DIFF CALC = .209 IS GREATER THAN THE CRITICAL VALUE

THEREFORE THE EXPONENTIAL DISTRIBUTION CANNOT BE ASSUMED

WEIBULL DISTR BUTION ASSUMED, ESTIMATED PARAMETERS ARE ALPHA = .60385E+00 BETA = .57073E+00

EST MEDIAN = 1.374 EST MEAN = 3.899 90 PER CENT LCL ON MEAN = 2.181 90 PER CENT UCL ON MEAN = 5.618

SPECIFIED MTTR = .75 HOURS LOWER CONF LIM 2.18 IS GREATER THAN MTTR, THUS A MAINTAINABILITY PROBLEM EXISTS

MAINTAINABILITY (REPAIR TIME)

ART-50 O-LEVEL SUMMARY

WRA	O-LEVEL BLOCK NO.		O-LEVEL NOMENCLATURE		NUMBER REPAIRS	LOWER 90 CONF LIM	UPPER 90 CONF LIM	SPEC MTTR	OBSERVED REPAIR TIMES LOW	MEAN	HIGH	MAINT PROBLEM
1	38		CHASSIS	784-7700	2.	.32	9.39	.8	1.0	2.00	3.0	NO
1	999				2.	.24	16.89	.8	1.0	2.50	4.0	NO
4	59	PJ8	INHBT DVR	784-4050	1.	NO CONF LIMITS		.8	8.0	8.00	8.0	
4	65		CORE MAG MEM	784-5626	1.	NO CONF LIMITS		.8	7.0	7.00	7.0	
4	67	PX2	CYCLE CTL I	784-4194	1.	NO CONF LIMITS		.8	8.0	8.00	8.0	
4	71	PW9	I/O SEL	784-4192	1.	NO CONF LIMITS		.8	1.0	1.00	1.0	
4	74	MTU	MAG TAPE	771-4616	2.	.24	16.89	.8	1.0	2.50	4.0	NO
4	88	PW2	MTA TMG	784-4180	1.	NO CONF LIMITS		.8	6.0	6.00	6.0	
4	999				6.	4.10	7.69	.8	3.0	6.33	13.0	YES
5	94	RVFR	FREQ REF	617-6876	2.	.39	394.13	.8	4.0	21.00	38.0	NO
5	103		BATTERY MODULE		1.	NO CONF LIMITS		.8	4.0	4.00	4.0	
5	106		CLOCK		1.	NO CONF LIMITS		.8	38.0	38.00	38.0	
5	108		CHASSIS		1.	NO CONF LIMITS		.8	1.0	1.00	1.0	
5	999				32.	1.93	2.66	.8	1.0	2.94	14.0	YES

MAINTAINABILITY (REPAIR TIME)

2K SUMMARY FOR ART-50 PROBLEM AREAS

JCN	SYSTEM	WRA	D-L	D-L	D-L	SYSTEM SYMPTON	DIAGNOSTIC	RESULTS
A46006076X620	5	4	65	0	0	NO LOAD		OPEN RUNS/PINS
A460060308760	5	5	999	0	0	NO 2ND HARM		R*R FTS A14 W/ A21
A460060528320	5	5	999	0	0	NO TIME ON	O-SCOPE	R*R FTS A21 W/ A20
A460060808390	5	1	999	0	0	NO LITE ON1	OVISUAL	R*R BUSTED PINS
A460062588900	5	5	999	0	0	GAINS 2M/HR		R*R FTS A14 W/ A7
A460063108730	5	5	103	999	0	NO BAT OPS		R*R BAT MODULE*MOD
A46006315A220	5	4	999	0	0	SWS*LITE BA	D	R*R PROCESSOR
A460063248460	5	4	999	0	0	NO PASS DIA	GMICRO	R*R PROC A2 W/ A21
A460070308730	5	4	999	0	0	NO LOAD		R*R PROC-NO FIX
A460070318740	5	4	999	0	0	NO LOAD		R*R PROC,
A460070448070	5	5	999	0	0	MISSN KNOB		R*R FTS A20 W/ A3
A460060059840	5	5	999	0	0	NO 5MHZ		R*R FTS A19 W/ A12
A460060289690	5	5	999	0	0	LOW 2ND HAR	M	R*R FTS A12 W/ A6
A460062759810	5	4	74	0	0	STUCK		R*R MTU B45 W/A140
A460062999540	5	5	999	0	0	NO 2ND HARM	LITE	R*R FTS A11 W/ A7
A460063169440	5	5	999	0	0	BUSTED WIRE		FIX PLUG J8
A46006334A140	5	4	65	0	0	NO LOAD	06 ERRO	RR*R PROC A14/ A12
A460070189210	5	5	999	0	0	TMG FAULT	LITE	R*R FTS A36 W/ A18
A460070080310	5	5	105	999	0	TMG FAULT	LITE	R*R FTS A36W/ A9
A460070150660	5	5	999	0	0	TMG FAULT	LITE	ADJ * ALIGNED FTS
A460070250480	5	5	999	0	0	TMG FAULT	LITE	R*R FTS A36 W/ A9
A460060123060	5	5	999	0	0	-1MIN/2 HR	CLOCK	R*R FTS
A460060773500	5	1	38	0	0	ROTRY SW ST	KSTUCK	R*R MOD A22 W/ A18
A460061153600	5	5	999	0	0	NO 2ND HARM		R*R FTS A15 W/ A9
A460061444270	5	4	67	0	0	BAD CHECKSU	MSELF	R*R PX-2 CARD
A460062994110	5	5	999	0	0	HAND STKS		R*R FTS A36 W/ A14
A450063314330	5	5	999	0	0	BUSTED CK W	R	R*R FTS A6 W/ A7
A460060065420	5	4	88	0	0	NOT PASS DI	AAUTOMAT	IR*R PW-2 CARD
A460060395440	5	5	999	0	0	MIN HAND FZ	N	R*R FTS A7 W/ A16
A460060395470	5	5	999	0	0	NO SWX BATT	.	R*R FTS A7 W/ A16
A460060715190	5	5	999	0	0	NO 2ND HARM	TF LITE	R*R FTS A21 W/ A55
A460060895130	5	4	74	0	0	PROC, FAILS	M20-120	R*R MTU A122 W/A17
A460060687140	5	1	38	0	0	BUSTED SW	VISUAL	R*R MOD A21 W/ A16
A460061507710	5	5	999	0	0	CLOCK INOP	POS = 3	R*R FTS
A460060586570	5	5	999	0	0	FAULT LITE	POS7- ,	6R*R FTS A7 W/ A20
A460063016640	5	4	65	0	0	NO PGM LD	LITE	R*R CORE STACK
A460063246720	5	4	999	0	0	BAD MS6 PRT	29J-BUS	TR*R PROC A12/A13
A460063306950	5	5	999	0	0	NO SW TO DC		NOT CONFIRMED
A46006340A080	5	5	999	0	0	FAULT LITE		R*R FTS A3 W/ A3
A460070436430	5	5	999	999	999	TMG FLT LIT	EP=7 O,	6R*R FTS A3 W/ A3
A460060331100	5	5	999	0	0	NO 5 MHZ SI	G	R*R FTS A19 W/ B6
A460061221330	5	5	999	0	0	LOW 5MHZ	POS =9	R*R FTS A36 W/ A3
A460061491250	5	5	999	0	0	SEC HND IND	PVISUAL	R*R FTS A3 W/ A9
A460062241320	5	5	999	0	0	LST 2ND HAR	M	R*R FTS A7 W/ A9
A460062581530	5	5	999	999	999	FLT LITE		R*R FTS "3 TIMES?
A460062811200	5	4	71	74	0	MTU BUST PI	N	R*R PW9 CARD MTU
A460063531090	5	4	59	999	0	NO LOAD PGM	LITE	R*R PJ8 PCB FTS
A460063551320	5	5	999	0	0	TMG FALT LI	TLITE	ADJ 2ND HARM
A460063131550	5	5	999	0	0	TMG FAULT	LITE	R*R FTS A36W/A6

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                    RMA SUMMARY ART-50      SYSTEM LEVEL
TTF DISTRIBUTION IS EXPONENTIAL WITH MEAN =    149.80

RT  DISTRIBUTION IS WEIBULL WITH ALPHA =    .43680 AND BETA =    .70740   MEAN =      4.04

          INHERENT AVAILABILITY = MTBF/(MTBF+MTTR)

MEAN TIME TO FAILURE  =    149.80

MEAN REPAIR TIME      =      4.04

INHERENT AVAILABILITY =     .9737
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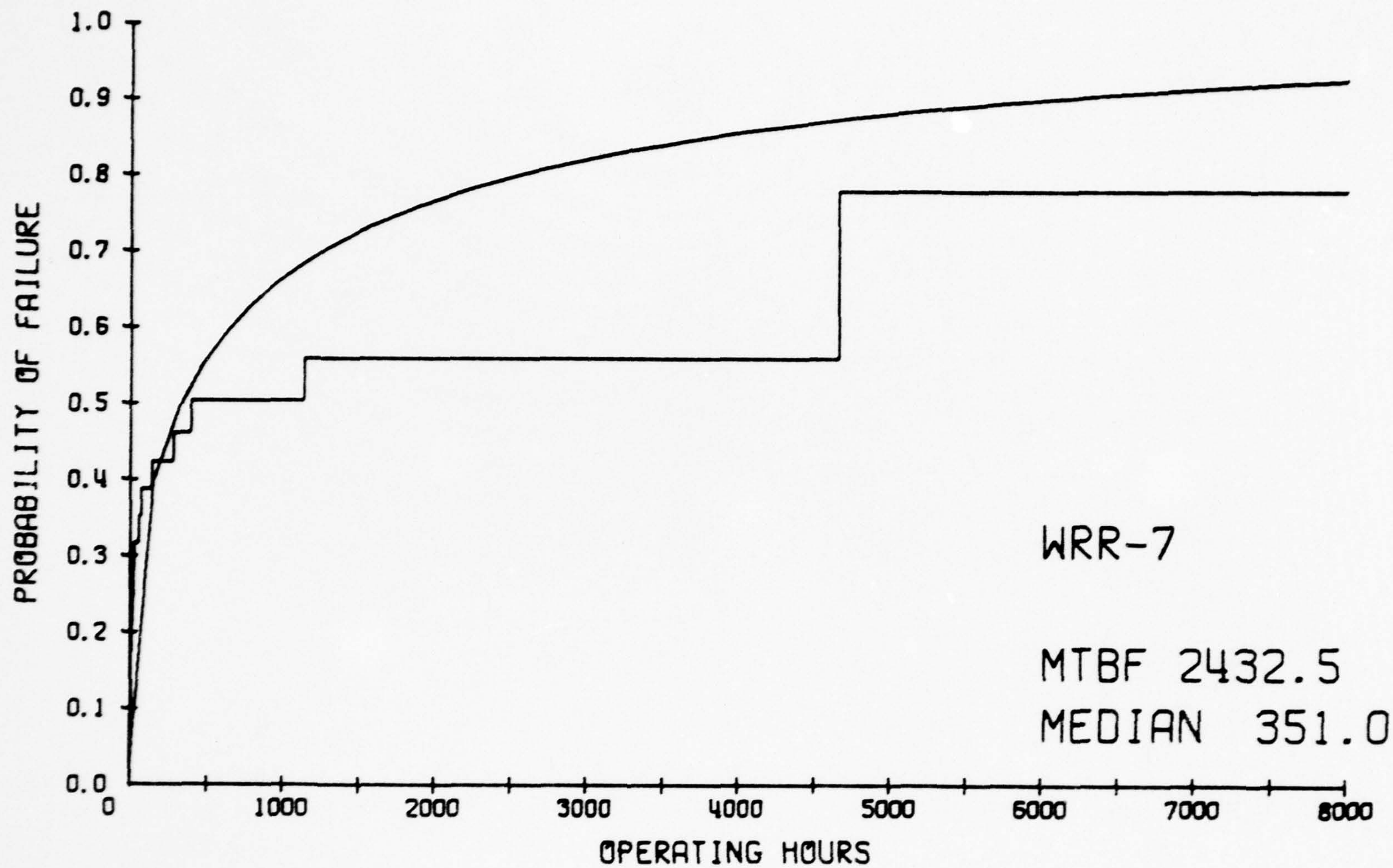
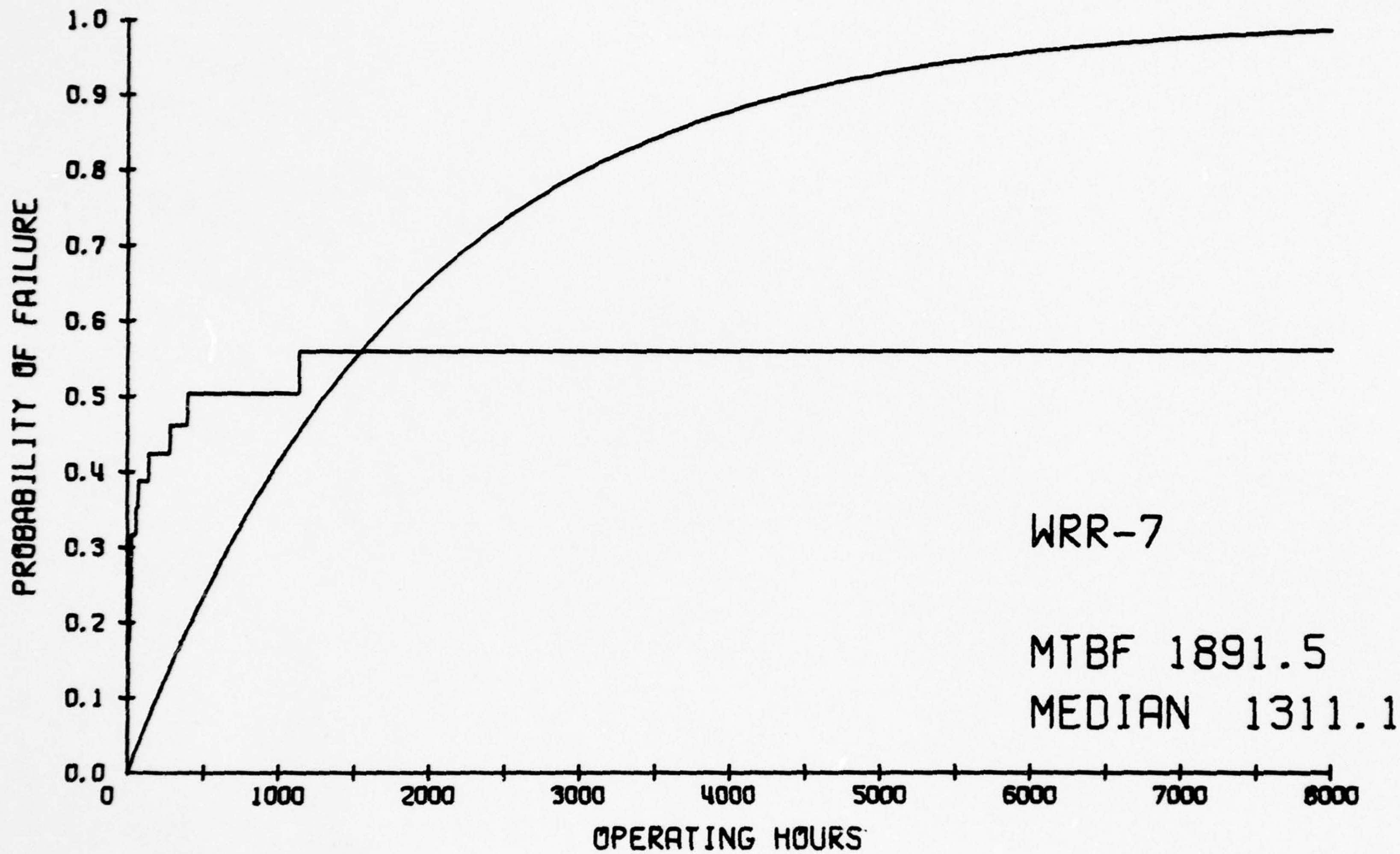
OUTPUT FOR AN/WRR-7

CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
WEIBULL PROBABILITY DISTRIBUTION FOR TIME TO FAILURE



CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO FAILURE



FLEET RELIABILITY ASSESSMENT DATA

MTYP	DATE		WRA	OL1	OL2	OL3	ETM	ETM1	ETM2	OPERATE	DUTY	TTF	SYS	UIC	SHIP NAME	HULL NO
0	6162	0	0	0	0	0	6163.0	0.0	0.0	0.0	0.000	0.0	4	46290	PROTEUS	AS 19
0	7040	0	0	0	0	0	1879.1	0.0	0.0	0.0	0.000	0.0	4	46290	PROTEUS	AS 19
0	7057	0	0	0	0	0	2659.0	0.0	0.0	0.0	0.000	0.0	4	46290	PROTEUS	AS 19
0	6159	0	0	0	0	0	3325.1	0.0	0.0	0.0	0.000	0.0	4	46890	HUNLEY	AS 31
3	6163	6163	1	999	0	0	0.0	3327.2	3327.2	2.1	.022	2.1	4	46890		
6	6166	6166	9	108	0	0	0.0	3332.2	3332.2	7.1	.042	5.0	4	46890		
3	6183	6183	1	10	18	0	0.0	3343.8	3343.6	18.7	.032	11.6	4	46890		
8	6286	6286	0	0	0	0	0.0	3543.6	3543.6	218.5	.072	199.8	4	46890		
0	7003	7005	1	10	2	0	1979.7	0.0	0.0	0.0	0.000	0.0	4	46890	HUNLEY	AS 31
3	7017	7018	5	999	0	0	0.0	2267.7	2267.7	288.0	.800	288.0	4	46890		
3	7063	7063	1	10	0	0	0.0	3420.0	3420.0	1440.3	1.000	1152.3	4	46890		
4	7082	7082	0	0	0	0	0.0	3808.7	3808.7	1829.0	.965	388.7	4	46890		
0	6201	0	0	0	0	0	884.3	0.0	0.0	0.0	0.000	0.0	4	46970	LAKE,SIMON	AS 33
3	6250	6250	4	85	0	0	0.0	950.2	950.8	65.9	.056	65.9	4	46970		
3	6282	6282	4	58	0	0	0.0	1355.2	1359.2	470.3	.242	404.4	4	46970		
4	7082	7082	0	0	0	0	0.0	2086.7	2086.7	1197.8	.203	727.5	4	46970		
NO INITIAL RECORD-FIRST RECORD USED																
3	6287	6288	1	4	0	0	1724.0	1720.0	1724.0	0.0	0.000	0.0	4	51100	ABRAHAM LINCOL	SSBN602
4	7057	7057	0	0	0	0	0.0	3909.0	3909.0	2185.0	.674	2185.0	4	51100		
NO INITIAL RECORD-FIRST RECORD USED																
4	7057	7057	0	0	0	0	3117.0	3117.0	3117.0	0.0	0.000	0.0	4	51102	ABRAHAM LINCOL	SSBN602
NO INITIAL RECORD-FIRST RECORD USED																
3	6357	6358	4	74	0	0	340.1	337.2	340.1	0.0	0.000	0.0	4	51160	ETHAN ALLEN	SSBN608
NO INITIAL RECORD-FIRST RECORD USED																
3	6167	6167	2	52	0	0	757.2	757.2	757.2	0.0	0.000	0.0	4	51170	SAM HOUSTON	SSBN609
3	6268	6268	5	94	0	0	0.0	768.0	772.0	10.8	.004	10.8	4	51170		
1	6306	0	0	0	0	0	809.0	809.0	0.0	47.8	.004	37.0	4	51170		
2	6306	6316	5	103	0	0	809.0	809.0	809.0	47.8	.013	37.0	4	51170		
1	6316	0	0	0	0	0	0.0	839.0	0.0	77.8	.013	30.0	4	51170		
2	6316	6322	2	48	0	0	839.0	839.0	839.0	77.8	.021	30.0	4	51170		
0	7006	7006	1	10	0	0	1312.0	1312.0	1312.0	0.0	0.000	0.0	4	51170	SAM HOUSTON	SSBN609
4	7057	7057	0	0	0	0	0.0	2029.0	2029.0	717.0	.586	717.0	4	51170		
0	6309	0	0	0	0	0	2610.4	0.0	0.0	0.0	0.000	0.0	4	51231	LAFAYETTE	SSBN616
4	7176	7176	0	0	0	0	0.0	5844.5	5844.5	3234.1	.581	3234.1	4	51231		
0	6309	0	0	0	0	0	2279.3	0.0	0.0	0.0	0.000	0.0	4	51232	LAFAYETTE	SSBN616
3	6311	6311	5	999	0	0	2279.5	2279.5	2279.5	.2	.004	.2	4	51232		
3	6325	6325	1	999	0	0	2302.1	2302.1	2302.1	22.8	.059	22.6	4	51232		
3	6337	6337	4	93	0	0	2280.2	2380.2	2380.2	100.9	.150	78.1	4	51232		
4	7176	7176	0	0	0	0	0.0	5126.1	5126.1	2846.8	.511	2745.9	4	51232		
0	6210	0	0	0	0	0	170.0	0.0	0.0	0.0	0.000	0.0	4	57011	MADISON,JAMES	SSBN627
8	6244	6244	0	0	0	0	0.0	178.0	178.0	8.0	.010	8.0	4	57011		
3	6252	6252	4	65	0	0	0.0	319.0	319.0	149.0	.148	149.0	4	57011		
4	7172	7172	0	0	0	0	0.0	3588.6	3588.6	3418.6	.436	3269.6	4	57011		
0	6210	0	0	0	0	0	172.0	0.0	0.0	0.0	0.000	0.0	4	57012	MADISON,JAMES	SSBN627
8	6232	6232	0	0	0	0	0.0	176.0	176.0	4.0	.008	4.0	4	57012		
8	6241	6241	0	0	0	0	0.0	177.0	177.0	5.0	.007	5.0	4	57012		
NO INITIAL RECORD-FIRST RECORD USED																
4	7172	7172	0	0	0	0	1141.9	1141.9	1141.9	0.0	0.000	0.0	4	57013	MADISON,JAMES	SSBN627
0	6219	0	0	0	0	0	3032.0	0.0	0.0	0.0	0.000	0.0	4	57131	KAMEHAMEHA	SSBN642
4	7117	7117	0	0	0	0	0.0	6900.5	6900.5	3868.5	.613	3868.5	4	57131		
0	6219	0	0	0	0	0	817.0	0.0	0.0	0.0	0.000	0.0	4	57132	KAMEHAMEHA	SSBN642
4	7117	7117	0	0	0	0	0.0	5484.3	5484.3	4667.3	.739	4667.3	4	57132		

FLEET RELIABILITY ASSESSMENT DATA

MTYP	DATE		WRA	OL1	OL2	OL3	ETM	ETM1	ETM2	OPERATE	DUTY	TTF	SYS	UIC	SHIP NAME	HULL NO
0	6207	0	0	0	0	0	459.7	0.0	0.0	0.0	0.000	0.0	4	57201	KEY,FRANCIS SC	SSBN657
6	6257	6310	1	18	10	0	297.5	477.5	477.5	17.8	.007	17.8	4	57201		
4	7105	7105	0	0	0	0	0.0	1413.9	1413.9	954.2	.151	936.4	4	57201		
0	6207	0	0	0	0	0	144.3	0.0	0.0	0.0	0.000	0.0	4	57202	KEY,FRANCIS SC	SSBN657
4	7105	7105	0	0	0	0	0.0	3297.8	3297.8	3153.5	.500	3153.5	4	57202		

90

R E L I A B I L I T Y

WRR-7 SYSTEM LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSURED	SURVIVORS	CPDF	EXPONENTIAL	MAX DIFFERENCE
.2	1.		28.	.034	.000	.034
2.1	1.		27.	.069	.001	.068
5.0	1.		26.	.103	.003	.101
5.0		1.				
10.8	1.		24.	.139	.006	.134
11.6	1.		23.	.175	.006	.169
17.8	1.		22.	.211	.009	.202
22.6	1.		21.	.247	.012	.235
30.0	1.		20.	.283	.016	.267
37.0	1.		19.	.319	.019	.299
65.9	1.		18.	.354	.034	.320
78.1	1.		17.	.390	.040	.350
149.0	1.		16.	.426	.076	.350
199.8		1.				
288.0	1.		14.	.464	.141	.323
388.7		1.				
404.4	1.		12.	.506	.192	.313
717.0		1.				
727.5		1.				
936.4		1.				
1152.3	1.		8.	.561	.456	.104
2185.0		1.				
2745.9		1.				
3153.5		1.				
3234.1		1.				
3269.6		1.				
3868.5		1.				
4667.3		1.				

R E L I A B I L I T Y

WRR-7 SYSTEM LEVEL

EQUIPMENT OPERATING HOURS (O.H.) = 28373.1 CALENDAR HOURS(C.H.) =, 64008.0 DUTY CYCLE (O.H./C.H.) = .443

NUMBER OF FAILURES = 15. OBSERVED FAILURE RATE/O.H. = .52867E-03

DISTRIBUTION DETERMINATION,

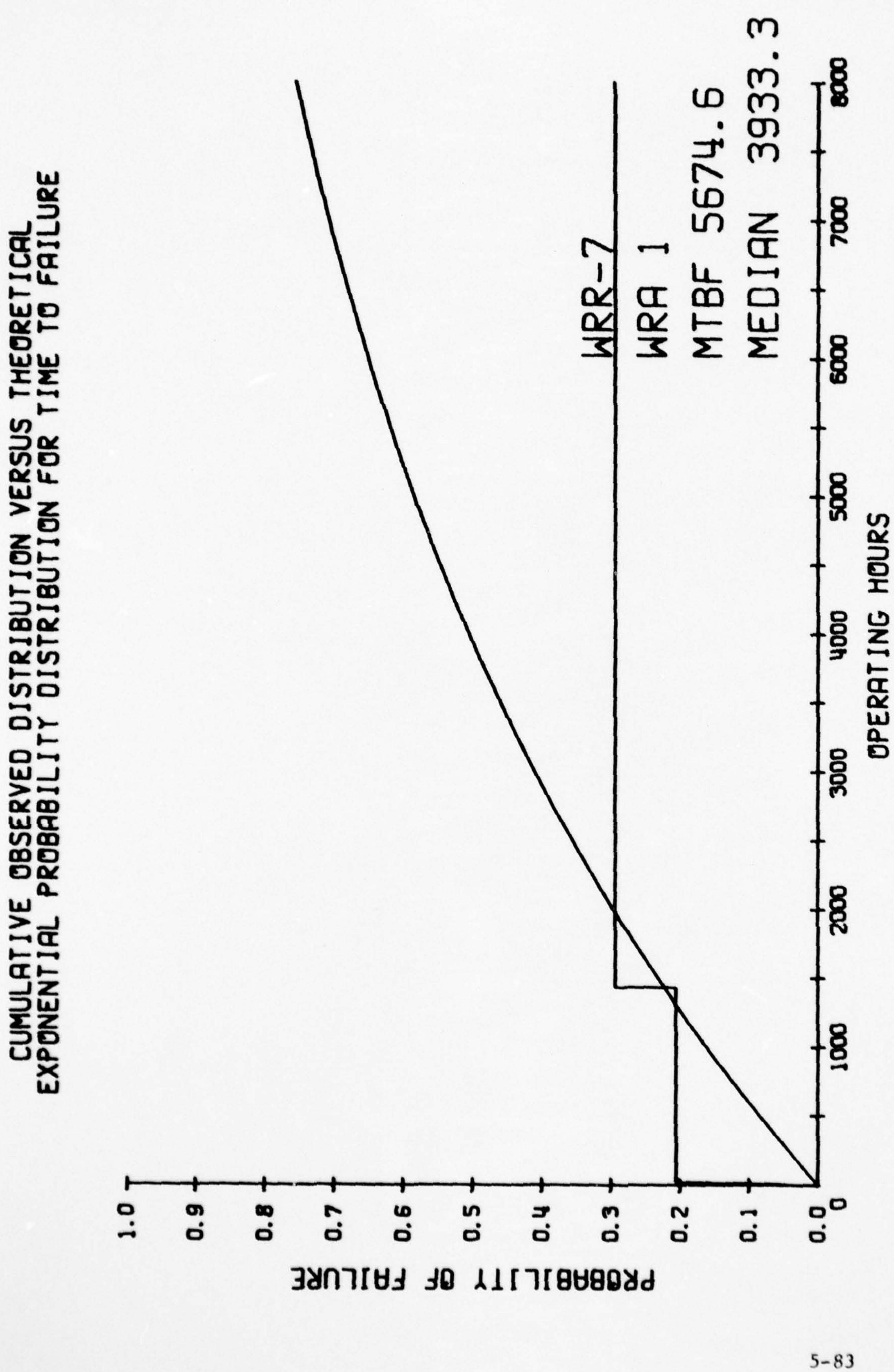
K-S CRITICAL VALUE (.10,15.) = .244

MAX DIFF CALC = .350, IS GREATER THAN CRITICAL VALUE THEREFORE THE WEIBULL DISTRIBUTION IS ASSUMED

THE WEIBULL PARAMETERS ARE ALPHA = .618166E-01 BETA = .415601E+00

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 2432.450, EST. MEDIAN = 351.020, 90 PER CENT LCL FOR MEAN = 0.000, 90 PER CENT UCL FOR MEAN = 4838.493


CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO FAILURE
PROBABILITY OF FAILURE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
6000
7000
8000
OPERATING HOURS
WRR-7
WRA 1
MTBF 5674.6
MEDIAN 3933.3

R E L I A B I L I T Y

ARR-7 WRA 1 LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSORED	SURVIVORS	CPDF	EXPONENTIAL	MAX DIFFERENCE
2.1	1.		19.	.050	.000	.050
5.0		1.				
16.6	1.		17.	.103	.003	.100
17.8	1.		16.	.156	.003	.152
22.8	1.		15.	.208	.004	.204
77.8		1.				
199.8		1.				
388.7		1.				
717.0		1.				
936.4		1.				
1197.8		1.				
1440.3	1.		8.	.296	.224	.072
2185.0		1.				
2824.0		1.				
3153.5		1.				
3234.1		1.				
3418.6		1.				
3868.5		1.				
4667.3		1.				

EQUIPMENT OPERATING HOURS (O.H.) = 28373.1 CALENDAR HOURS(C.H.) =, 64008.0 DUTY CYCLE (O.H./C.H.) = .443

NUMBER OF FAILURES = 5, OBSERVED FAILURE RATE/O.H. = .17622E-03

DISTRIBUTION DETERMINATION,

K-S CRITICAL VALUE (.10, 5.) = .406

MAX DIFF CALC = .204, IS LESS THAN CRITICAL VALUE THEREFORE THE EXPONENTIAL DISTRIBUTION IS ASSUMED

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 5674.620, EST. MEDIAN = 3933.347, 90 PER CENT LCL FOR MEAN = 3059.2, 90 PER CENT UCL FOR MEAN = 11663.741

90 PERCENT UCL 11663.74 IS GREATER THAN 2900.00 HOURS, THEREFORE THE EQUIPMENT MEETS THE SPECIFICATIONS

R E L I A B I L I T Y

WPR-7 WRA 2 LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSORED
5.0		1.
77.8	1.	
218.5		1.
717.0		1.
954.2		1.
1197.8		1.
1829.0		1.
2185.0		1.
2846.8		1.
3153.5		1.
3234.1		1.
3418.6		1.
3868.5		1.
4667.3		1.

EQUIPMENT OPERATING HOURS (O.H.) = 28373.1 CALENDAR HOURS(C.H.) =, 64008.0 DUTY CYCLE (O.H./C.H.) = .443

NUMBER OF FAILURES = 1. OBSERVED FAILURE RATE/O.H. = .35245E-04

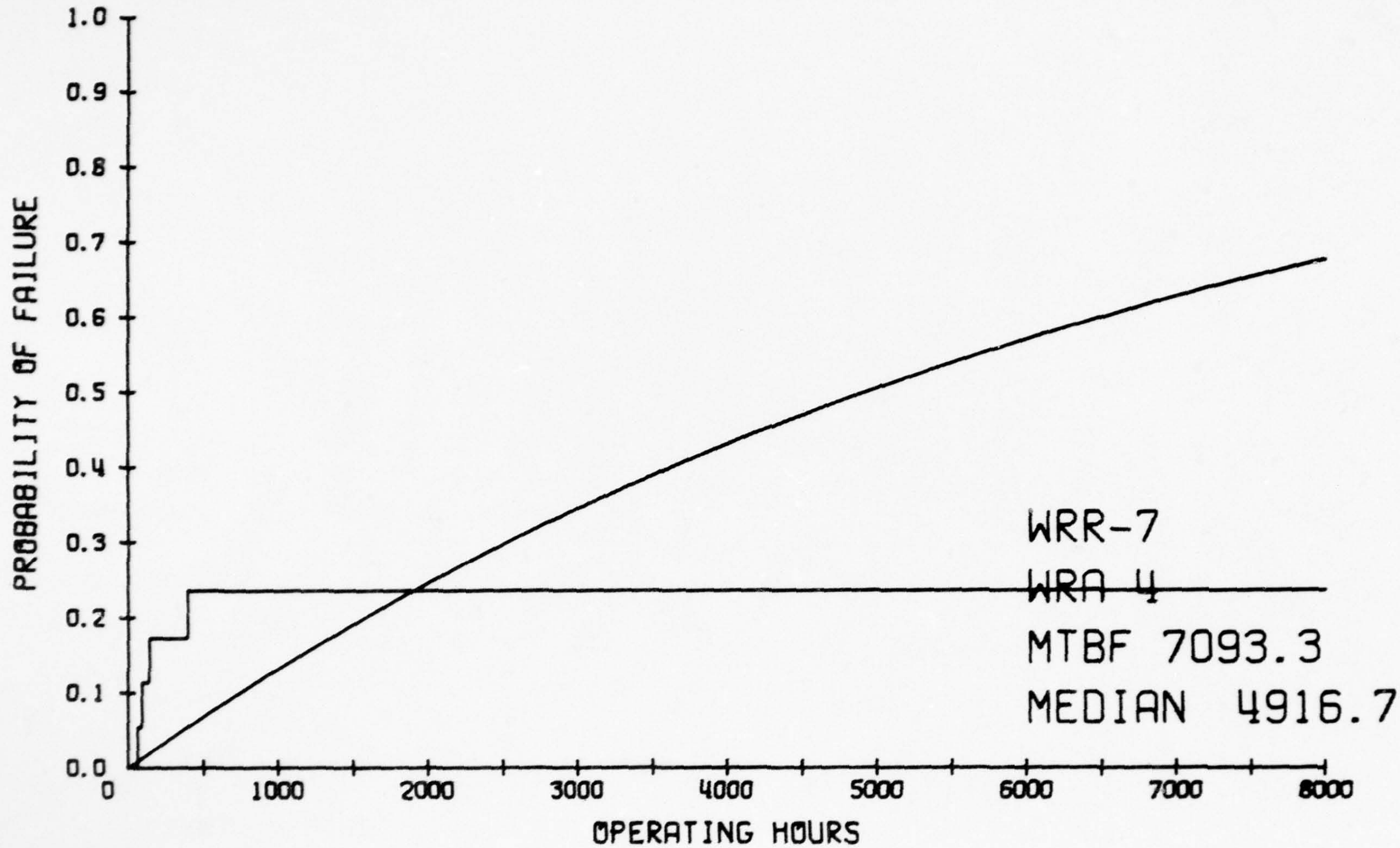
LESS THAN FOUR FAILURES THE EXPONENTIAL DISTRIBUTION IS ASSUMED

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 28373.100, EST. MEDIAN = 19666.734, 90 PER CENT LCL FOR MEAN = 7294.4, 90 PER CENT UCL FOR MEAN = 269296.697

90 PERCENT UCL 269296.70 IS GREATER THAN 10500.00 HOURS, THEREFORE THE EQUIPMENT MEETS THE SPECIFICATIONS

CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO FAILURE



R E L I A B I L I T Y

WRR-7 RA 4 LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSORED	SURVIVORS	CPDF	EXPONENTIAL	MAX DIFFERENCE
5.0		1.				
65.9	1.		17.	.056	.009	.046
77.8		1.				
100.9	1.		15.	.115	.014	.100
149.0	1.		14.	.174	.021	.153
218.5		1.				
404.4	1.		12.	.237	.055	.182
717.0		1.				
727.5		1.				
954.2		1.				
1829.0		1.				
2185.0		1.				
2745.9		1.				
3153.5		1.				
3234.1		1.				
3269.6		1.				
3868.5		1.				
4667.3		1.				

EQUIPMENT OPERATING HOURS (O.H.) = 28373.1 CALENDAR HOURS(C.H.) =, 64008.0 DUTY CYCLE (O.H./C.H.) = .443

NUMBER OF FAILURES = 4. OBSERVED FAILURE RATE/O.H. = .14098E-03

DISTRIBUTION DETERMINATION,

K-S CRITICAL VALUE (.10, 4.) = .449

MAX DIFF CALC = .182, IS LESS THAN CRITICAL VALUE THEREFORE THE EXPONENTIAL DISTRIBUTION IS ASSUMED

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 7093.275, EST. MEDIAN = 4916.684, 90 PER CENT LCL FOR MEAN = 3549.5, 90 PER CENT UCL FOR MEAN = 16261.800

90 PERCENT UCL 16261.80 IS GREATER THAN 800.00 HOURS, THEREFORE THE EQUIPMENT MEETS THE SPECIFICATIONS

AD-A068 859 NAVAL WEAPONS SUPPORT CENTER CRANE IN F/G 5/2

FLEET RELIABILITY ASSESSMENT PROGRAM. VOLUME 5. AN/URC-62 VLF F--ETC(U)

SEP 77

UNCLASSIFIED NL

2 OF 2

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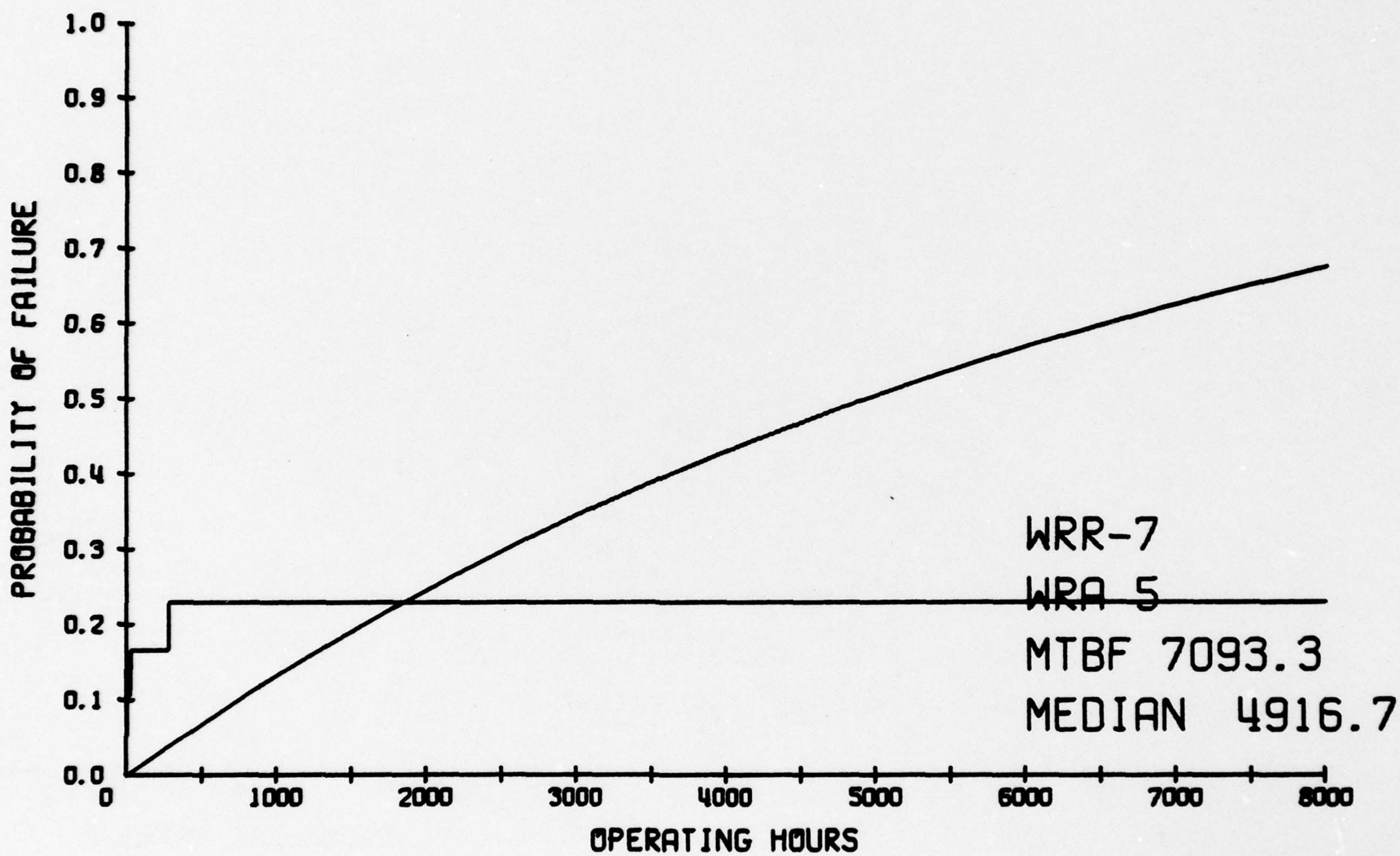
CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO FAILURE



R E L I A B I L I T Y

ARR-7 GRA 5 LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSORED	SURVIVORS	CPDF	EXPONENTIAL	MAX DIFFERENCE
.2	1.		18.	.053	.000	.053
5.0		1.				
10.8	1.		16.	.108	.002	.107
30.0		1.				
37.0	1.		14.	.168	.005	.163
218.5		1.				
288.0	1.		12.	.232	.040	.192
717.0		1.				
954.2		1.				
1197.8		1.				
1541.0		1.				
2185.0		1.				
2846.6		1.				
3153.5		1.				
3234.1		1.				
3418.6		1.				
3868.5		1.				
4667.3		1.				

EQUIPMENT OPERATING HOURS (O.H.) = 28373.1 CALENDAR HOURS(C.H.) =, 64008.0 DUTY CYCLE (O.H./C.H.) = .443

NUMBER OF FAILURES = 4. OBSERVED FAILURE RATE/O.H. = .14098E-03

DISTRIBUTION DETERMINATION,

K-S CRITICAL VALUE (.10, 4.) = .449

MAX DIFF CALC = .192, IS LESS THAN CRITICAL VALUE THEREFORE THE EXPONENTIAL DISTRIBUTION IS ASSUMED

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 7093.275, EST. MEDIAN = 4916.684, 90 PER CENT LCL FOR MEAN = 3549.5, 90 PER CENT UCL FOR MEAN = 16261.800

90 PERCENT UCL 16261.80 IS GREATER THAN 2900.00 HOURS, THEREFORE THE EQUIPMENT MEETS THE SPECIFICATIONS

R E L I A B I L I T Y

WRR-7 .RA 9 LEVEL

TIME TO FAIL	NO. FAILURES	NO. CENSORED
5.0		1.
7.1	1.	
77.8		1.
211.4		1.
717.0		1.
954.2		1.
1197.8		1.
1829.0		1.
2185.0		1.
2846.8		1.
3153.5		1.
3234.1		1.
3418.6		1.
3868.5		1.
4667.3		1.

EQUIPMENT OPERATING HOURS (O.H.) = 28373.1 CALENDAR HOURS(C.H.) =, 64008.0 DUTY CYCLE (O.H./C.H.) = .443

NUMBER OF FAILURES = 1. OBSERVED FAILURE RATE/O.H. = .35245E-04

LESS THAN FOUR FAILURES THE EXPONENTIAL DISTRIBUTION IS ASSUMED

FOR THE ASSUMED DISTRIBUTION

EST. MEAN = 28373.100, EST. MEDIAN = 19666.734, 90 PER CENT LCL FOR MEAN = 7294.4, 90 PER CENT UCL FOR MEAN = 269296.697

90 PERCENT UCL 269296.70 IS LESS THAN 2000000.00 HOURS, THUS A RELIABILITY PROBLEM EXISTS

100

R E L I A B I L I T Y

WRR-7 O-LEVEL SUMMARY

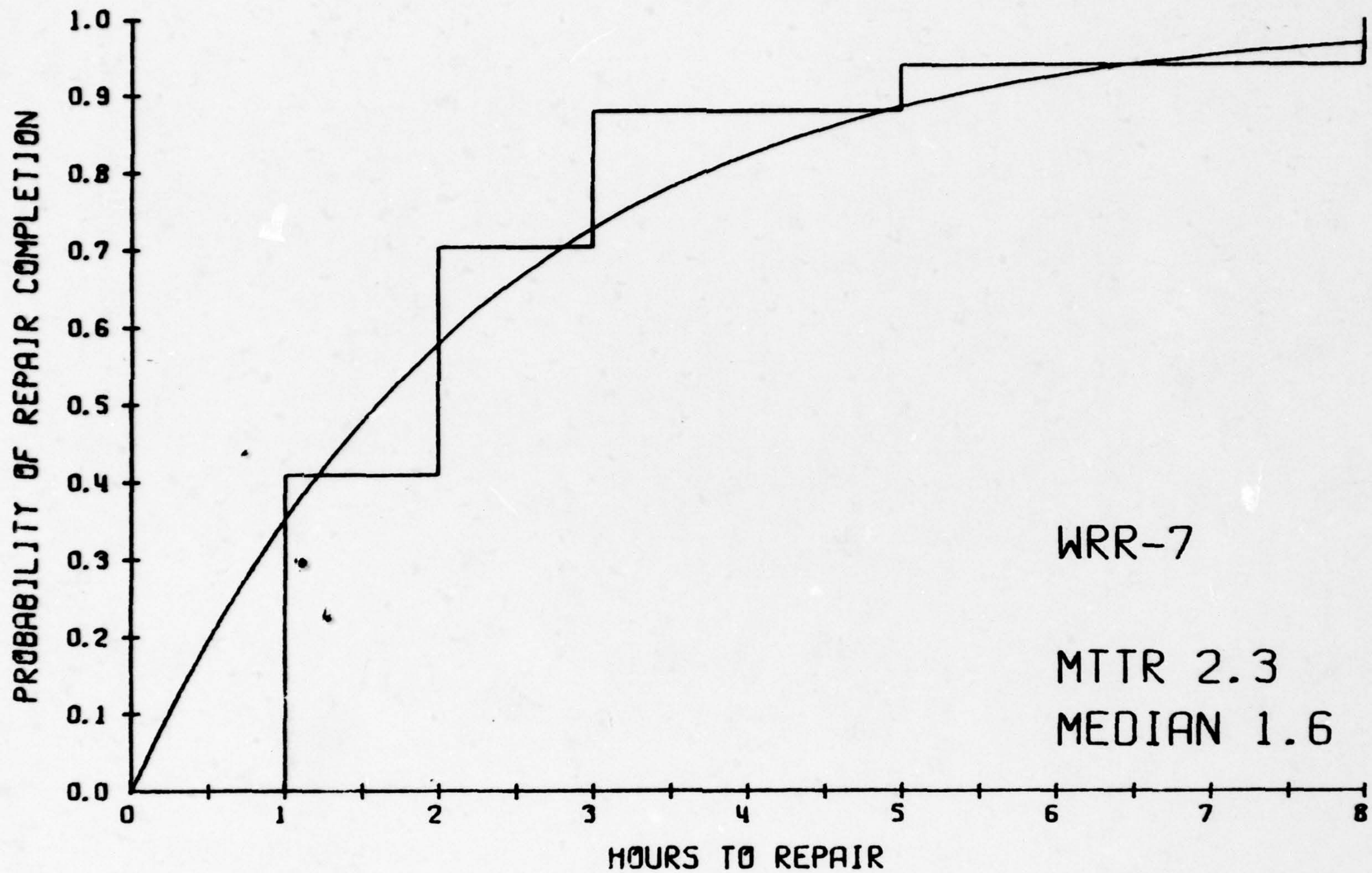
WRA	O-LEVEL BLOCK NO.		O-LEVEL NOMENCLATURE		NUMBER FAILURES	LOWER 90 CONF LIM	MEAN	UPPER 90 CONF LIM	SPEC MTBF	OBSERVED FAILURE TIMES LOW	HIGH	RELIAB PROBLEM
1	10		POWER SUPPLY	616-1789	3.	4246,96	9457.70	25745,40	26900,00	17,80	1440.30	YES
1	18		SMO	792-6701	2.	5330,98	14186,55	53351,80	11600,00	17,90	18.70	NO
1	999				2.	5330,98	14186.55	53351,80	2000000,00	2,10	22,80	YES
2	48	RA5	-25V	784-3655	1.	7294,38	28373.10	269296,70	44843,00	77,80	77,80	NO
4	58	PE7	P/W DVR	784-3992	1.	7294,38	28373.10	269296.70	61633,00	470,30	470,30	NO
4	65	CORE	CORE MAGNETIC MEM	784-5626	1.	7294,38	28373.10	269296,70	50000.00	149,00	149,00	NO
4	85	PY4	CMPR ACC	784-4212	1.	7294,38	28373,10	269296,70	52654,00	65,90	65,90	NO
4	93		CHASSIS		1.	7294,38	28373.10	269296.70	10907,00	100,90	100,90	NO
5	94	A5	RVFR	617-6876	1.	7294,38	28373.10	269296,70	12500.00	10,80	10,80	NO
5	103	A10	BATTERY	606-9524	1.	7294,38	28373.10	269296,70	500000,00	47,80	47,80	YES
5	999				2.	5330,98	14186.55	53351,80	2000000,00	.20	288,00	YES
9	108		CHASSIS	606-9513	1.	7294,38	28373.10	269296,70	37800,00	7,10	7.10	NO

R E L I A B I L I T Y

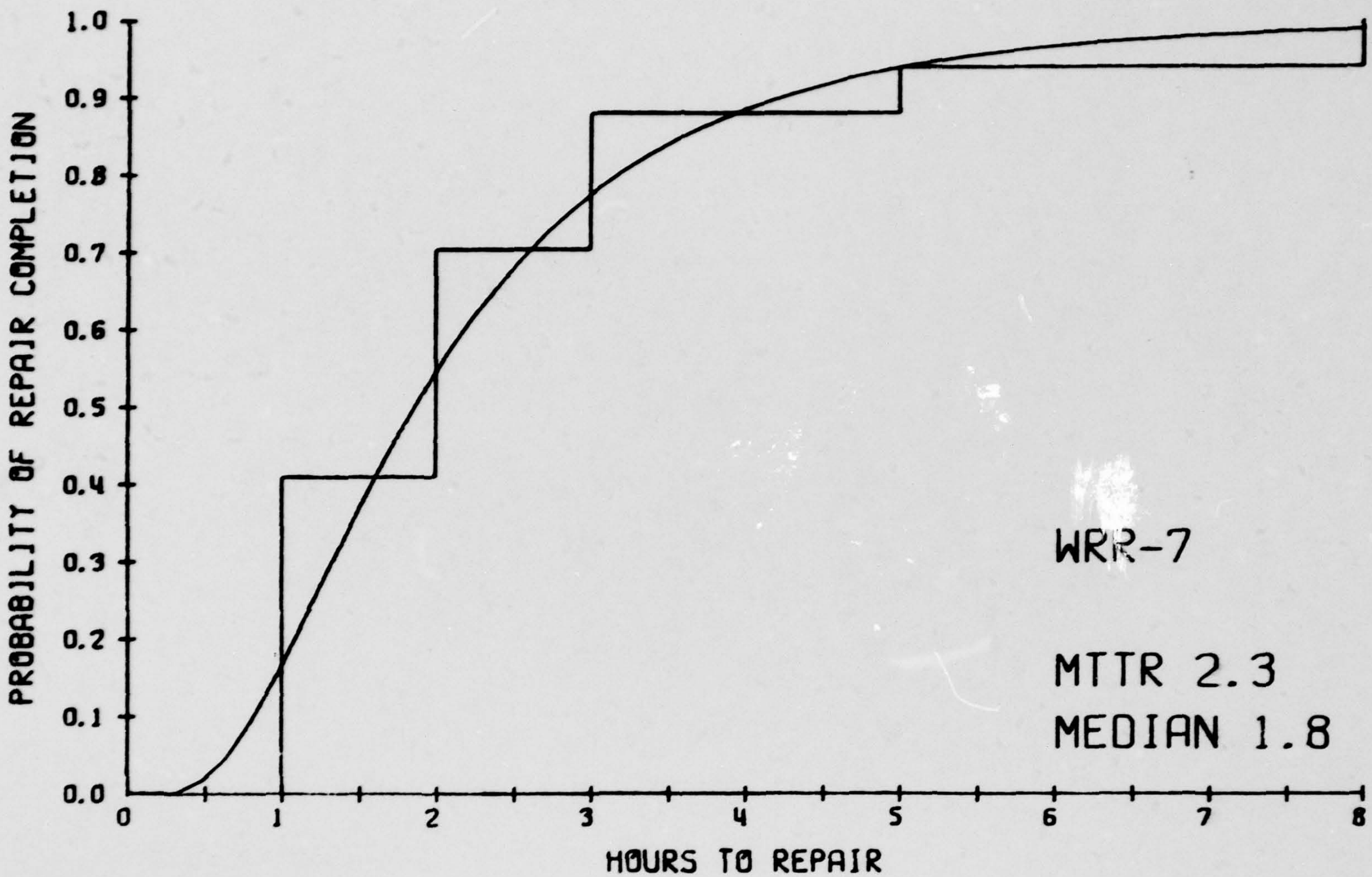
2K SUMMARY FOR WRR-7 PROBLEM AREAS

JCN	SYSTEM	WRA	D-L	D-L	D-L	SYSTEM SYMPTON	DIAGNOSTIC	RESULTS
04689CE010856	4	1	999	0	0	BLWN FUSE		R+R FUSE
04689CE010853	4	9	108	0	0	SMASHED SWS		PERSONNEL
04689CE010858	4	1	10	18	0	BLO FUSE		R+R A6A8 1N R1738
04689CE010971	4	1	10	2	0	SMO OUTA LC	KLITE	R+R PWR SUPT 1MIX
04689CE010985	4	5	999	0	0	LO 2ND HARM		ADJ+CHNG MTR R
04689CE011018	4	1	10	0	0	BLUE FUSES		R+R RCVR PS MODULE
05117DC010460	4	5	103	0	0	TIME LOSS	NO DC L	TR+R BATTERY MODULE
05117DC010483	4	1	10	0	0			R+R PWR SUPPLY
05123DC010605	4	5	999	0	0	TM6 FAULT	LITE	R+R FTS
0512306010608	4	1	999	0	0	BLUE FUSE		R+R F3
05720DC010423	4	1	18	10	0	LOCK, FUZE	LIT, BL	NR+R SMO + RC PR SP

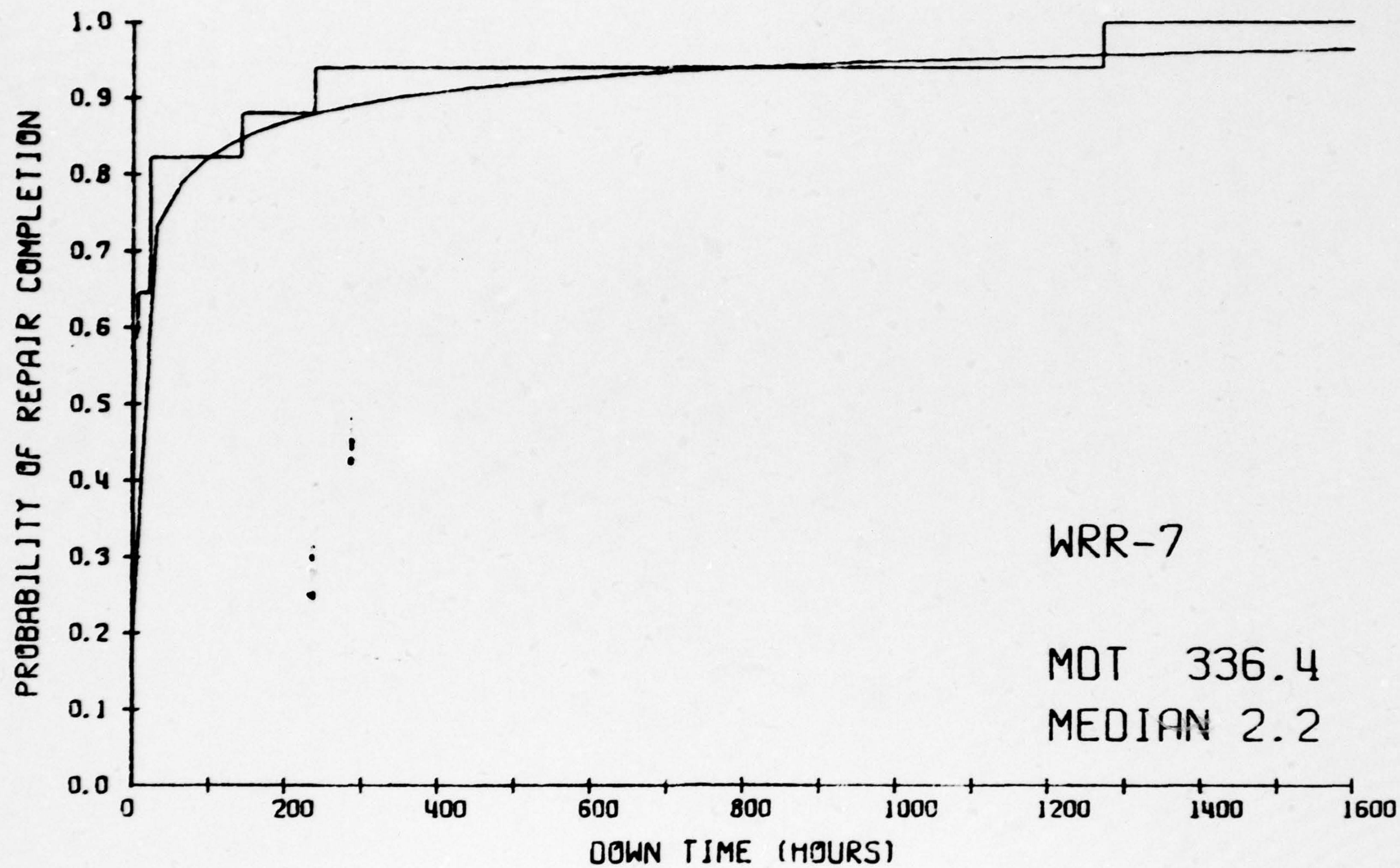
CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR TIME TO REPAIR



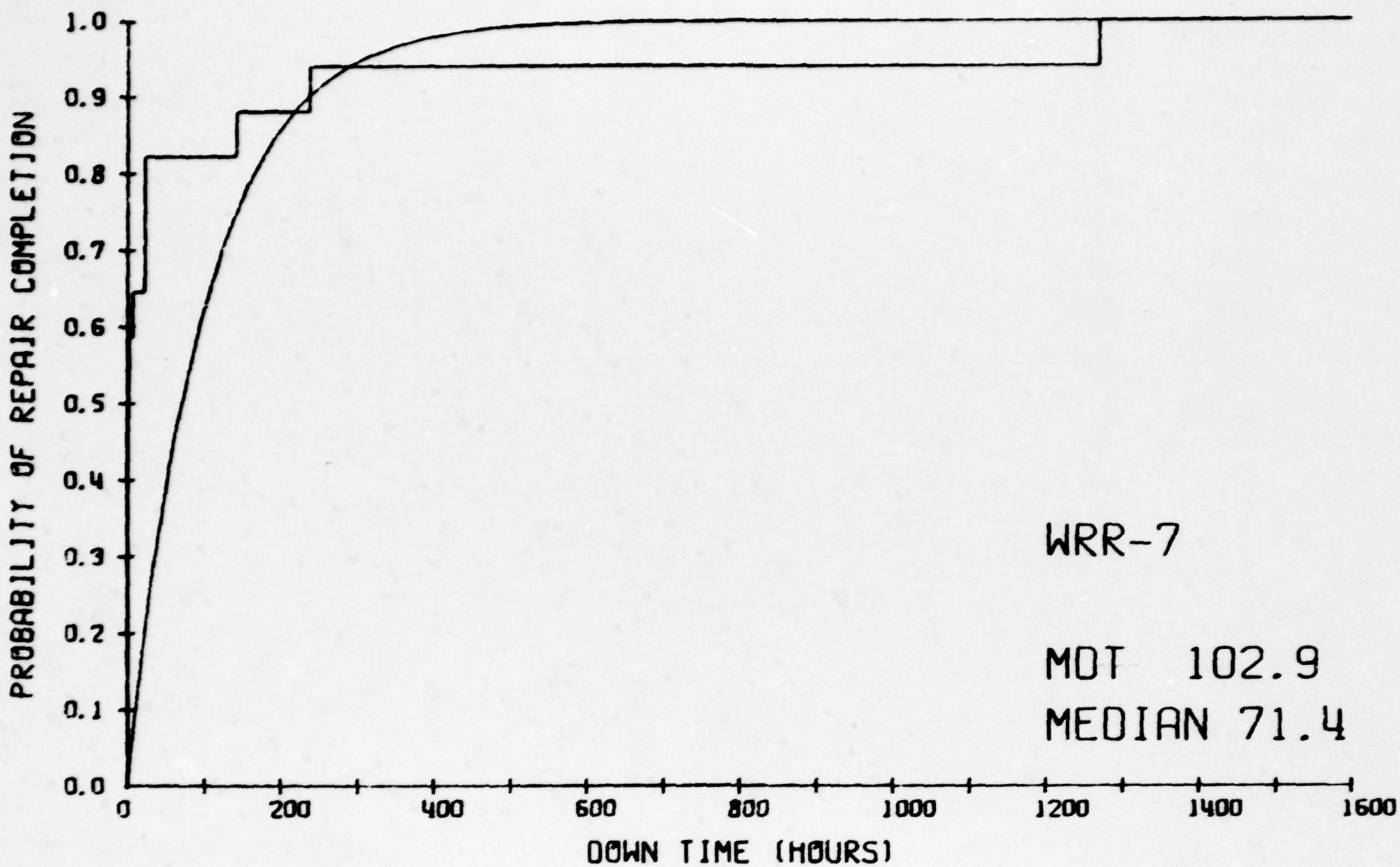
CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
LOGNORMAL PROBABILITY DISTRIBUTION FOR TIME TO REPAIR



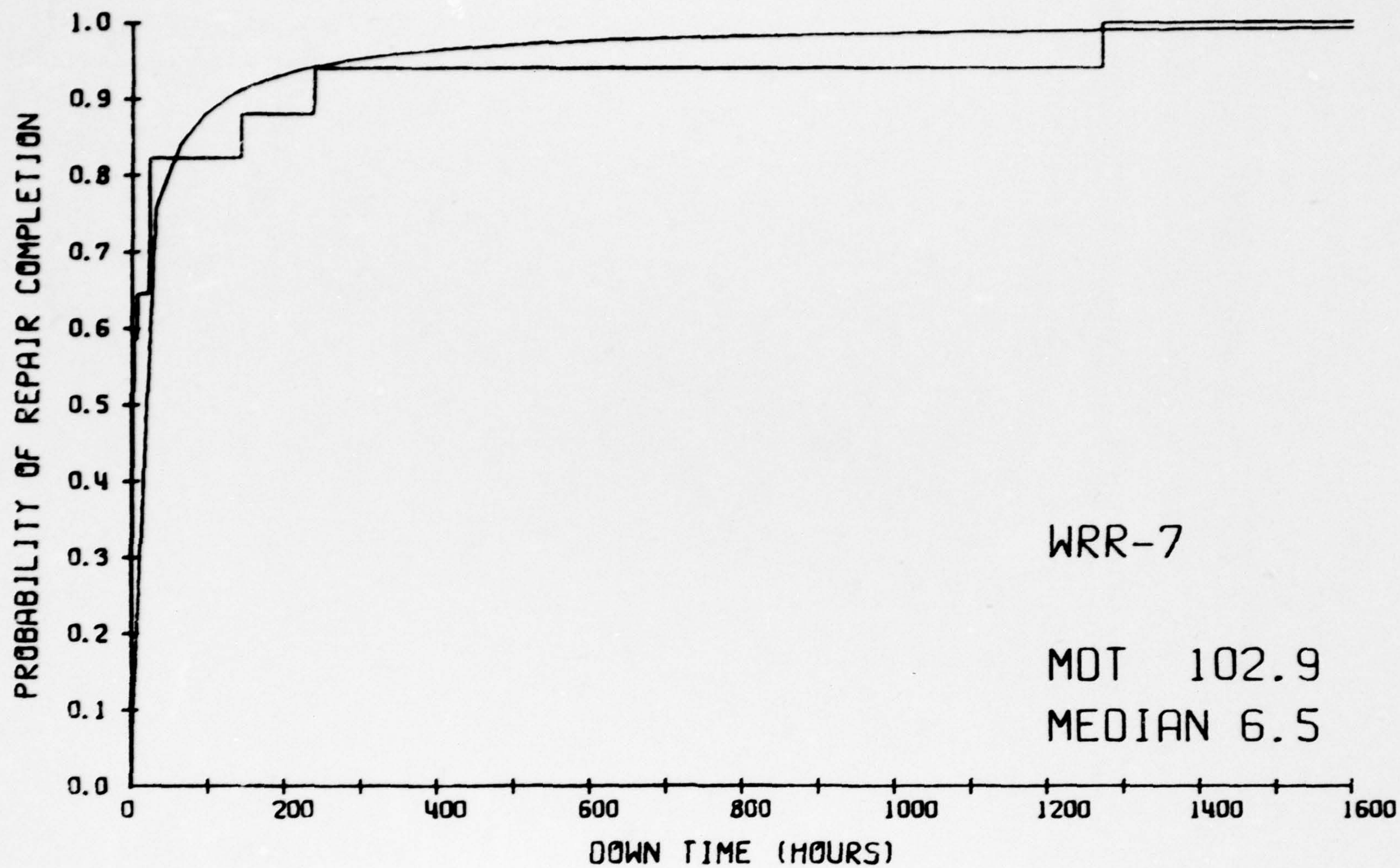
CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
WEIBULL PROBABILITY DISTRIBUTION FOR DOWN TIME



CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
EXPONENTIAL PROBABILITY DISTRIBUTION FOR DOWN TIME



CUMULATIVE OBSERVED DISTRIBUTION VERSUS THEORETICAL
LOGNORMAL PROBABILITY DISTRIBUTION FOR DOWN TIME



FLEET MAINTAINABILITY ASSESSMENT DATA

WRA	OL1	OL2	OL3	DISCOVERY DATE	COMPLETION DATE	DOWN TIME (HRS)	REPAIR TIME (HRS)	SYS	UIC
1	999	0	0	6163	6163	1.0	1.0	4	04689
9	108	0	0	6166	6166	1.0	1.0	4	04689
1	10	18	0	6183	6183	2.0	2.0	4	04689
5	999	0	0	7017	7018	24.0	2.0	4	04689
1	10	0	0	7063	7063	1.0	1.0	4	04689
4	85	0	0	6250	6250	1.0	1.0	4	04697
4	58	0	0	6282	6282	8.0	8.0	4	04697
1	4	0	0	6287	6288	24.0	2.0	4	05110
4	76	0	0	6357	6358	24.0	5.0	4	05116
2	52	0	0	6167	6167	1.0	1.0	4	05117
5	96	0	0	6268	6268	2.0	2.0	4	05117
5	103	0	0	6306	6316	240.0	3.0	4	05117
2	48	0	0	6316	6322	144.0	2.0	4	05117
5	999	0	0	6311	6311	3.0	3.0	4	05123
1	999	0	0	6325	6325	1.0	1.0	4	05123
4	93	0	0	6337	6337	1.0	1.0	4	05123
4	65	0	0	6252	6252	0.0	0.0	4	05701
				NO REPAIR TIME FOR THE ABOVE RECORD					
1	18	10	0	6257	6310	1272.0	3.0	4	05720

MAINTAINABILITY (REPAIR TIME)

WRR-7 SYSTEM LEVEL

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
1.0	7.	7.0	.389	.168	.221
2.0	5.	12.0	.667	.569	.160
3.0	3.	15.0	.833	.776	.109
5.0	1.	16.0	.889	.960	.107
8.0	1.	17.0	.944	.989	.100

TOTAL REPAIR HOURS = 39.0 NUMBER OF REPAIRS = 17. OBSERVED REPAIR RATE/HR = .4359E+00

DISTRIBUTION DETERMINATION

MEAN OF LN'S = .61 STD DEV OF LN'S = .64

K-S CRITICAL VALUE (.10, 17.) = .189 MAX DIFF CALC = .221 IS GREATER THAN THE CRITICAL VALUE

THEREFORE THE LOGNORMAL DISTRIBUTION CANNOT BE ASSUMED

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	EXPONENTIAL	MAX DIFFERENCE
1.0	7.	7.	.389	.333	.036
2.0	5.	12.	.667	.582	.193
3.0	3.	15.	.833	.730	.104
5.0	1.	16.	.889	.887	.054
8.0	1.	17.	.944	.969	.081

TOTAL REPAIR HOURS = 39.0 NUMBER OF REPAIRS = 17. OBSERVED REPAIR RATE/HR = .4359E+00

DISTRIBUTION DETERMINATION

K-S CRITICAL VALUE (.10, 17.) = .229 MAX DIFF CALC = .193 IS LESS THAN THE CRITICAL VALUE

THEREFORE THE EXPONENTIAL DISTRIBUTION IS ASSUMED

EST MEAN = 2.29 EST MEDIAN = 1.59 90 PER CENT LCL ON MEAN = 1.74 90 PER CENT UCL ON MEAN = 3.25

SPECIFIED MTTR = .62 HOURS LOWER CONF LIM 1.74 IS GREATER THAN MTTR, THUS A MAINTAINABILITY PROBLEM EXISTS

MAINTAINABILITY (DOWN TIME)

WRR-7 SYSTEM LEVEL

DOWN TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
1.0	7.	7.0	.389	.207	.182
2.0	2.	9.0	.500	.304	.196
3.0	1.	10.0	.556	.369	.187
8.0	1.	11.0	.611	.537	.074
24.0	3.	14.0	.778	.717	.106
144.0	1.	15.0	.833	.913	.135
240.0	1.	16.0	.889	.963	.110
1272.0	1.	17.0	.944	.990	.101

TOTAL DOWN TIME (TDT) = 1750.0 NUMBER OF REPAIRS (NR) = 17. OBSERVED DOWN TIME/REPAIR (TDT/NR) = 102.94

DISTRIBUTION DETERMINATION

MEAN OF LN'S = 1.86 STD DEV OF LN'S = 2.28

K-S CRITICAL VALUE (.10, 17.) = .189 MAX DIFF CALC = .196 IS GREATER THAN THE CRITICAL VALUE

THEREFORE THE LOGNORMAL DISTRIBUTION CANNOT BE ASSUMED

DOWN TIME	FREQUENCY	CUM FREQUENCY	NPF	EXPONENTIAL	MAX DIFFERENCE
1.0	7.	7.	.389	.010	.379
2.0	2.	9.	.500	.019	.481
3.0	1.	10.	.556	.029	.527
8.0	1.	11.	.611	.075	.536
24.0	3.	14.	.778	.208	.570
144.0	1.	15.	.833	.753	.080
240.0	1.	16.	.889	.903	.070
1272.0	1.	17.	.944	1.000	.111

TOTAL DOWN TIME (TDT) = 1750.0 NUMBER OF REPAIRS (NR) = 17. OBSERVED DOWN TIME/REPAIR (TDT/NR) = 102.94

DISTRIBUTION DETERMINATION

K-S CRITICAL VALUE (.10, 17.) = .229 MAX DIFF CALC = .570 IS GREATER THAN THE CRITICAL VALUE

THEREFORE THE EXPONENTIAL DISTRIBUTION CANNOT BE ASSUMED

WEIBULL DISTRIBUTION ASSUMED, ESTIMATED PARAMETERS ARE ALPHA = .58208E+00 BETA = .23643E+00

EST MEDIAN = 2.217 EST MEAN = 336.398 90 PER CENT LCL ON MEAN = 0.000 90 PER CENT UCL ON MEAN =1386.865

MAINTAINABILITY (REPAIR TIME)

WRR-7 WRA 1 LEVEL

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
1.0	3.	3.0	.429	.193	.236
2.0	2.	5.0	.714	.721	.292
3.0	1.	6.0	.857	.924	.210

TOTAL REPAIR HOURS = 10.0 NUMBER OF REPAIRS = 6. OBSERVED REPAIR RATE/HR = .6000E+00

DISTRIBUTION DETERMINATION

MEAN OF LN'S = .41 STD DEV OF LN'S = .48

LESS THAN FOUR DISTINCT REPAIR TIMES

THEREFORE THE LOGNORMAL DISTRIBUTION IS ASSUMED

EST MEAN = 1.67 EST MEDIAN = 1.51 90 PER CENT LCL ON MEDIAN = 1.13 90 PER CENT UCL ON MEDIAN = 2,02

SPECIFIED MTTR = .62 HOURS LOWER CONF LIM 1.13 IS GREATER THAN MTTR, THUS A MAINTAINABILITY PROBLEM EXISTS

MAINTAINABILITY (REPAIR TIME)

WRR-7 WRA 2 LEVEL

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
1.0	1.	1.0	.333	.260	.094
2.0	1.	2.0	.667	.760	.427

TOTAL REPAIR HOURS = 3.0 NUMBER OF REPAIRS = 2. OBSERVED REPAIR RATE/HR = .6667E+00

DISTRIBUTION DETERMINATION

MEAN OF LN'S = .35 STD DEV OF LN'S = .49

LESS THAN FOUR DISTINCT REPAIR TIMES

THEREFORE THE LOGNORMAL DISTRIBUTION IS ASSUMED

EST MEAN = 1.50 EST MEDIAN = 1.41 90 PER CENT LCL ON MEDIAN = .49 90 PER CENT UCL ON MEDIAN = 4.11

SPECIFIED MTTR = .62 HOURS LOWER CONF LIM .49 IS LESS THAN MTTR, THUS THE EQUIPMENT MEETS THE SPECIFICATIONS

MAINTAINABILITY (REPAIR TIME)

WRR-7 WRA 4 LEVEL

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
1.0	2.	2.0	.400	.197	.203
5.0	1.	3.0	.600	.737	.337
8.0	1.	4.0	.800	.858	.258

TOTAL REPAIR HOURS = 15.0 NUMBER OF REPAIRS = 4. OBSERVED REPAIR RATE/HR = .2667E+00

DISTRIBUTION DETERMINATION

MEAN OF LN'S = .92 STD DEV OF LN'S = 1.08

LESS THAN FOUR DISTINCT REPAIR TIMES

THEREFORE THE LOGNORMAL DISTRIBUTION IS ASSUMED

EST MEAN = 3.75 EST MEDIAN = 2.51 90 PER CENT LCL ON MEDIAN = 1.04 90 PER CENT UCL ON MEDIAN = 6.10

SPECIFIED MTTR = .62 HOURS LOWER CONF LIM 1.04 IS GREATER THAN MTTR, THUS A MAINTAINABILITY PROBLEM EXISTS

MAINTAINABILITY (REPAIR TIME)

WRR-7 WRA 5 LEVEL

REPAIR TIME	FREQUENCY	CUM FREQUENCY	NPF	LOGNORMAL	MAX DIFFERENCE
2.0	2.	2.0	.400	.193	.207
3.0	2.	4.0	.800	.807	.407

TOTAL REPAIR HOURS = 10.0 NUMBER OF REPAIRS = 4. OBSERVED REPAIR RATE/HR = .4000E+00

DISTRIBUTION DETERMINATION

MEAN OF LN'S = .90 STD DEV OF LN'S = .23

LESS THAN FOUR DISTINCT REPAIR TIMES

THEREFORE THE LOGNORMAL DISTRIBUTION IS ASSUMED

EST MEAN = 2.50 EST MEDIAN = 2.45 90 PER CENT LCL ON MEDIAN = 2.02 90 PER CENT UCL ON MEDIAN = 2.97

SPECIFIED MTTR = .62 HOURS LOWER CONF LIM 2.02 IS GREATER THAN MTTR, THUS A MAINTAINABILITY PROBLEM EXISTS

MAINTAINABILITY (REPAIR TIME)

WRR-7 WRA 9 LEVEL

LESS THAN FOUR DISTINCT REPAIR TIMES

THEREFORE THE LOGNORMAL DISTRIBUTION IS ASSUMED

ONLY ONE DISTINCT REPAIR TIME -- NO CONFIDENCE LIMITS

MAINTAINABILITY (REPAIR TIME)

WRR-7 O-LEVEL SUMMARY

WRA	O-LEVEL BLOCK NO.		O-LEVEL NOMENCLATURE		NUMBER REPAIRS	LOWER 90 CONF LIM	UPPER 90 CONF LIM	SPEC MTTR	OBSERVED REPAIR TIMES LOW	MEAN	HIGH	MAINT PROBLEM
1	6		SECOND I F	616-1710	1.	NO CONF LIMITS		.6	2.0	2.00	2.0	
1	10		POWER SUPPLY	616-1789	3.	.99	3.33	.6	1.0	2.00	3.0	YES
1	18		SMD	792-6701	2.	1.31	4.57	.6	2.0	2.50	3.0	YES
1	999				2.	NO CONF LIMITS		.6	1.0	1.00	1.0	
2	48	RA5	-25V	784-3655	1.	NO CONF LIMITS		.6	2.0	2.00	2.0	
2	52	RB2	-5.2V	784-3659	1.	NO CONF LIMITS		.6	1.0	1.00	1.0	
4	58	PE7	P/W DVR	784-3992	1.	NO CONF LIMITS		.6	8.0	8.00	8.0	
4	74	MTU	TAPE UNIT	777-4616	1.	NO CONF LIMITS		.6	5.0	5.00	5.0	
4	85	PV6	CMPR ACC	784-4212	1.	NO CONF LIMITS		.6	1.0	1.00	1.0	
4	93		CHASSIS		1.	NO CONF LIMITS		.6	1.0	1.00	1.0	
5	94	A5	RVPR	617-6876	1.	NO CONF LIMITS		.6	2.0	2.00	2.0	
5	103	A10	BATTERY	606-9524	1.	NO CONF LIMITS		.6	3.0	3.00	3.0	
5	999				2.	1.31	4.57	.6	2.0	2.50	3.0	YES
9	108		CHASSIS	606-9513	1.	NO CONF LIMITS		.6	1.0	1.00	1.0	

MAINTAINABILITY (REPAIR TIME)

2K SUMMARY FOR WRR-7 PROBLEM AREAS

JCN	SYSTEM	WRA	D-L	D-L	D-L	SYSTEM SYMPTOM	DIAGNOSTIC	RESULTS
04689CE010856	4	1	999	0	0	BLWN FUSE		R+R FUSE
04689CE010858	4	1	10	18	0	BLD FUSE		R+R A6A8 1N R1738
04689CE010971	4	1	10	2	0	SHD OUTA LC	KLITE	R+R PWR SUPT 1MIX
04689CE010985	4	5	999	0	0	LO 2ND HARM		ADJ+CHNG MTR R
04689CE011018	4	1	10	0	0	BLUE FUSES		R+R RCVR PS MODULE
04697CE018469	4	4	85	0	0	HV LITE -5.	2STEP 26	R R PY-4 SEE PIXS
04697CE018480	4	4	58	0	0	NO PTR	39 "857	R+R PE-7 CARD
05110DC010554	4	1	4	0	0	FAILS DIAG	STEP 27	R R MODULE A5
05116DC010614	4	4	74	0	0	NO LOAD		R+R MTU S/N A65
05117DC010447	4	5	94	0	0	TMG FAULT	LITE	R+R RVFR
05117DC010460	4	5	103	0	0	TIME LOSS	NO DC L	TR+R BATTERY MODULE
05117DC010483	4	1	10	0	0			R+R PWR SUPPLY
05123DC010605	4	5	999	0	0	TMG FAULT	LITE	R+R FTS
05123DG010608	4	1	999	0	0	BLUE FUSE		R+R F3
05123DC010612	4	4	93	0	0	BAD LITE TS	T	R+R LAMP MRC W-2
05701DC010652	4	4	65	0	0	BLN CORE	-25V BK	RR+R CPU W/843 CPU
05720DC010423	4	1	18	10	0	LOCK, FUZE	LIT, BL	MR+R SMD + RC PR SP

RMA SUMMARY WRR-7 SYSTEM LEVEL

TTF DISTRIBUTION IS WEIBULL WITH ALPHA = .06182 AND BETA = .41560 MEAN = 2432.50

DT DISTRIBUTION IS WEIBULL WITH ALPHA = .58200 AND BETA = .23640 MEAN = 336.40

RT DISTRIBUTION IS EXPONENTIAL WITH MEAN = 2.29

INHERENT AVAILABILITY = MTBF/(MTBF+MTTR)

MEAN TIME TO FAILURE = 2432.50

MEAN REPAIR TIME = 2.29

INHERENT AVAILABILITY = .9991

OBSERVED AVAILABILITY (SIMULATION OF RATIOS TTF/(TTF+DT))

90 PERCENT LCL ON INDIVIDUALS = .1575

90 PERCENT UCL ON INDIVIDUALS = .9964

MEAN = .8094

MEDIAN = .9818